Spread Glottis Implementation in Germanic

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1. Introduction

The phonetic gesture of stop consonant aspiration, which is predictable in a Germanic language such as English, has been described traditionally as ranging from 'a puff of air' upon release of closure (Heffner 1950) to segmental occurrence of a following voiceless glottal approximant /h/ (Trager & Smith 1951). Within the generative phonology paradigm, however, aspiration has been construed as a featural property rather than as an independent segment of its own, often casually identified simply as [+aspiration], or, following Chomsky & Halle (1968), as a positive specification resulting from 'heightened subglottal pressure'. We take this kind of view here as well, employing a notation with superscripted 'h'([C^h])to indicate representations in which

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aspiration is encoded as an integral feature of the segment with which it is
associated, while we explore the phonological realization of aspiration in
Germanic as the reflex manifestation of a spread or open glottis, an idea
first advanced in the seminal work of Kim (1970). The paper thus reviews
the phonetics and phonology of the laryngeal gesture [spread glottis], and
seeks to bring together a set of superficially unrelated phenomena in Germanic,
synchronic (principally, aspiration and sonorant devoicing in English) as well
as diachronic (principally, Grimm’s Law and its exceptions in obstruent
clusters). In passing, we outline a phonetic motivation for the shift of voiceless
stops to fricatives diachronically, and further suggest, inspired by Kohler
(1984), that the salient property defining the voicing contrast in Germanic
languages like English is the ‘fortis’ feature [spread glottis], not [voice] as
in Romance or Slavic. We also identify some of the consequences that this
distinction in phonetic typology may hold for the phonology, predicting, in
particular, that assimilation to voicing occurs only in languages for which
[voice] is a marked feature. For the English-type of language, then, in
which only voicelessness spreads throughout obstruent clusters, laryngeal
markedness is the reverse of what has generally been assumed, viz. the
voiced obstruents are unmarked, the voiceless identified via [spread glottis].

2. Glottal width and aspiration.

Kim (1970) observed that, in Korean, there are actually two degrees of
aspiration in the laryngeally three-way distinctive stop system. Besides a
series of glottally ‘tense’ voiceless unaspirated stops (/p t č k’/), Korean
has both heavily aspirated (/pʰ tʰ čʰ kʰ/) and lightly aspirated voiceless
stops (/p t ċ k/= [p’ t’ č’ k’]) contrasting in syllable-initial position.1) Rather

1) In syllable-final position, laryngeal manner contrasts are neutralized to the unreleased
than attribute aspiration just to a delay in the onset of voicing for a following vowel, as suggested by the cross-linguistic survey of Voice Onset Time (VOT) variations conducted by Lisker & Abramson (1964), Kim proposed that aspiration is the automatic, aerodynamic result of a spread glottis configuration in the larynx. Thus, as abducted vocal folds begin to come together after release of oral closure in order to produce voicing in a following vowel, a certain amount of time passes before the vocal folds achieve the adducted state necessary for phonation. Up to that point, the vocal folds are not in contact, and air exiting the trachea during the period of post-release voicelessness is perceived as 'aspiration'. In Kim’s (1970:77) words, "...it seems safe to assume that aspiration is nothing but a function of the glottal opening at the time of release. This is to say that if a stop is n degree aspirated, it must have an n degree glottal opening at the time of release of the glottal closure." 2) In Korean, then, the heavily aspirated series can be characterized as having the linguistically maximum degree of glottal width (around 10 mm, based on Kim’s cineradiographic tracings, representable as [spread glottis]), whereas the lightly aspirated or lax series has an only slightly open glottis in which the vocal folds are neither particularly abducted nor adducted (an opening of around 3 mm, glottis neither spread nor constricted), while the laryngeal configuration of the tense series has the vocal folds in rather tight approximation (less than 1 mm of opening, [constricted glottis]).

This three-way division of glottal width and the identification of aspiration as ensuing from a specification of [spread glottis] have been

stops [p' t' k']; additionally, the lightly aspirated series is voiced to [b d j g] in intervocalic contexts—cf. Iverson (1983a, 1989).

2) Similarly, Ladefoged (1993:142) holds that "In general, the degree of aspiration (the amount of lag in the voice onset time) will depend on the degree of glottal aperture during the closure. The greater the opening of the vocal cords during a stop, the longer the amount of the following aspiration."
integrated into the laryngeal feature framework worked out by Halle & Stevens (1971), and continue to form part of the distinctive feature stock of current phonological theory (Clements 1985, Goldsmith 1990, Kenstowicz 1994). But the 'puff of air' of aspiration does not always result from a specification of [spread glottis]. In particular, as Kim pointed out well prior to the development of modern autosegmental representation, there is no aspiration produced within a syllable-internal cluster of voiceless obstruents in words like *spit*, even though the glottis is spread. In essence, Kim suggested that the reason English stops are not aspirated after /s/ is that these clusters contain but a single specification of [spread glottis], shared between the fricative and the stop:

...the glottal movement for /p/ of /sp/ will start during /s/, i.e., the glottis will begin to widen. This means that, if the glottis is instructed to open to the same degree and for the same period for /p/ of /sp/ as it would for initial /p/, the glottis will begin to close by the time the closure for /p/ is made, and consequently, by the time /p/ is released, the glottis will have become so narrow that the voicing for the following vowel will immediately start, and thus we have an unaspirated /p/ after /s/. Note that the notion of simultaneous compatibility is crucial here, i.e., since /s/ is voiceless and does not require the closing of the glottis, the opening of the glottis for /p/ does not have to wait for the completion of /s/ but can proceed simultaneously with the oral articulation of /s/. (1970:80)

Indeed, the peak of glottal opening associated with this gesture in the cluster /sp/ lies in (the latter portion of) the /s/, as will be described below.3)

Though the glottis progressively narrows until achieving voicing in the

3) A similar wide glottis configuration is known to attend the fricative /s/ in Korean even as a singleton (following fiberscopic data reported by Kagaya 1974; cf. also Iverson 1983b).
following vowel, as in singleton stops, in /sp/ the period of 'aspiration' is consumed in the oral closure phase of the stop member of the cluster. Assuming a largely constant duration for the specification of [spread glottis] (which equates with the constancy of the 'voiceless interval', or VLI, as laid out for English by Weismer 1980), the absence of aspiration in /s/-clusters thus reduces to the observation that the narrowing glottis which characterize the latter portion of the [spread glottis] specification is associated with the stop in the cluster, whereas the presence of aspiration in singleton stops reflects association of a narrowing glottis with the release phase of the stop (equivalently, with the initial portion of the following vowel):

\[
\begin{align*}
\text{Cluster:} & \quad & \text{Singleton:} \\
\text{p} & \quad \text{p}^h \\
\text{V} & \quad \text{V} \\
\text{[sp gl]} & \quad \text{[sp gl]} \\
\end{align*}
\]

There is considerable phonetic as well as phonological evidence that the [spread glottis] specification in clusters is shared. Nothing that especially sibilant fricatives, like /s/, require a large glottal aperture in order to produce air flow high enough to sustain their characteristic turbulence, Kingston (1990) cites experimental work using photoelectric glottography on voiceless obstruents, both singly and in clusters, from several languages—Swedish, Japanese, Icelandic, as well as English (Löfqvist & Yoshioka 1981, Yoshioka, Löfqvist, & Hirose 1981). For all of these, in single fricatives the peak of glottal opening is coordinated with the beginning of oral constriction. In single stops the peak occurs later, at the point of oral release, but in clusters there is only one such gesture:

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

This observation parallels those by Browman & Goldstein (1986) or Goldstein (1990:447) "... that words may begin with at most one glottal gesture", and is consistent with a feature representation for obstructed clusters of the sort in (1), in which the same laryngeal gesture has domain over both members of the cluster, however, it runs afoul of traditional phonological accounts wherein the [spread glottis] feature (or [aspiration]) is not present in either segment to begin with, and instead is added by rule to voiceless stops only at the beginning of the word or stressed syllable (see below). The fact is, however, that [spread glottis] cannot be a property just of word and syllable initial stop, because it also occurs in single fricatives and in clusters composed of fricative plus stop, in which case the gesture does not occur twice, once for each of the two voiceless segments, but rather is shared between them.


Phonologically, the Obligatory Contour Principle (OCP, McCarthy 1986) forces tautomorphic adjacent identical specifications to reduce to one shared one in any event. That is, a morpheme-internal sequence of /s/ followed by /p/ could contain at most one instance of [spread glottis] per the OCP, hence the necessity of representation like those in (1) rather than independent specification of [spread glottis] for each voiceless obstructed in a cluster. Through spreading, however, the [spread glottis] gesture comes to be shared even with adjacent sonorant consonants, which are not
specified one way or the other for this feature to begin with:

(2) plan [plæn] crow [kɹɔ] slip [slɪp] 
    shrimp [ʃɪmp] sneeze [sŋɪz] fleet [fɪlt]

On the interpretation that aspiration equates with voicelessness, i.e., that both phenomena are realizations of an open glottis, a unified explanation becomes available for the compound fact that, in /s/-clusters, (a) stops are not aspirated and (b) sonorant consonants are voiceless, viz.:

(3) In obstruent-initial consonant clusters, the feature [spread glottis] is shared.

In spit the single [spread glottis] gesture in the syllable onset is shared between the /s/ and the /p/, as it is between the /s/ and the /l/ in slip: in the former case, ‘aspiration’ is absorbed by the voiceless stop’s oral closure, in the latter case it is manifested as voiceless in an otherwise spontaneously voiced sonorant. The basic constancy of the English VLI affects longer clusters, too, as in street or split: but here the duration of the single [spread glottis] gesture is generally consumed by the two obstruent members of the cluster—as verified in the experimental work of Repp (1984), the following sonorant remains voiced [(stliːt), [splɪt], not *[stʃiːt], *[splʃɪt].4) The constraint expressed in (3) accounts automatically for this distribution, in contrast to

4) In formal elicitations conducted under laboratory conditions, Repp (1984:118–119) found that voicelessness does not extend into the liquid in three-member /s/-clusters (e.g., the /p/ in splash exhibited “...an initial 10-ms release burst, which preceded the first glottal pulse of the [l] segment”). Perhaps in faster speech, with shorter segment durations, the [spread glottis] gesture may have domain over the initial portion of the sonorant member in a triconsonantal cluster, but Repp did not find this experimentally. The extent of the spread of this feature appears to be just a function of the composite duration of the segments, whatever their number, that comprise the cluster with which the feature is associated.
proposals which posit for English a regressive assimilatory rule of sonorant consonant devoicing (Hoard 1971, Kiparsky 1979, Nespor & Vogel 1986, Jensen 1993), because such a rule does not distinguish voicelessness in initial stops (which otherwise results in aspiration) from its occurrence in clusters (which does not). This empirical difficulty does not arise if the voicelessness of the liquids and nasals in the words of (2) is taken to be due to the sharing of a [spread glottis] gesture which inheres in voiceless obstruents.\(^5\)

In languages whose voiceless stops are uniformly unaspirated and in which [spread glottis] accordingly plays neither a phonemic nor a phonetic role, e.g., Spanish (or Polish, French, Czech, Hungarian), sonorant consonants remain predictably voiced after initial voiceless obstruents, as in [tres] ‘three’, [florida] ‘florida’, etc. This difference now derives not from the presence of a sonorant devoicing rule in English versus its absence in Spanish, but rather from the general dynamics of [spread glottis] implementation, a feature which simply is not represented in Spanish. On this account, furthermore, there is no rule of aspiration per se in English (or, of course, Spanish), either—instead, the aspirated quality of initial voiceless stops in English ensues from their basic [spread glottis] property, which, by universal phonetic implementation, trails off into a narrowed glottis configuration toward the end of its occurrence, after the release of oral closure in singleton stops but essentially simultaneous with it in obstruent-initial clusters. Thus, assumption of a fundamentally constant duration for the specification of [spread glottis] result in the variable VOT distributions commonly observed in English and other languages, i.e., no delay upon release of closure in obstruent cluster (unaspirated stops), but substantial lag upon release of

\(^5\) Cho (1991) presents an overview of languages in which (unlike English) voicing in sonorants is contrastive, arguing as here that the appropriate representation of voiceless sonorants is with [spread glottis], not the absence of [voice].
singletons (aspirated stops). In languages such as Spanish, on the other hand, for which [spread glottis] is not distinctive there is essentially no lag in VOT upon closure release, and hence no aspiration.

4. English aspiration distributions.

The conventional understanding of aspiration in English, however, is that the feature which characterizes it (say, [+aspiration] or [+spread glottis]) is added by rule to voiceless stops in certain contexts, elsewhere they remain unaspirated. Since the influential metrical work of Kiparsky (1979), the two main contexts in which aspirated stops are found in English—at the beginning of word or at the beginning of a stressed syllable—have been unified into a single environment, viz., the initial position of a stress foot. Nespor & Vogel (1986:90–91) cite several examples in which the stop /t/ is aspirated and others in which it is not, illustrating how the difference correlates with independently determined foot structure (foot constituency is labeled with 'Σ'):

\[(4)\]

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>a.</td>
<td>time</td>
<td>( \rightarrow [t^h]ime )</td>
<td>[time]Σ</td>
</tr>
<tr>
<td>b.</td>
<td>tuna</td>
<td>( \rightarrow [t^h]una )</td>
<td>[tuna]Σ</td>
</tr>
<tr>
<td>c.</td>
<td>toucan</td>
<td>( \rightarrow [t^h]oucan )</td>
<td>[tou]Σ [can]Σ</td>
</tr>
<tr>
<td>d.</td>
<td>typhoon</td>
<td>( \rightarrow [t^h]typhoon )</td>
<td>[ty]Σ [phoon]Σ</td>
</tr>
<tr>
<td>e.</td>
<td>terrain</td>
<td>( \rightarrow [t^h]terrain )</td>
<td>[te]Σ [rain]Σ</td>
</tr>
<tr>
<td>f.</td>
<td>detain</td>
<td>( \rightarrow de[t^h]ain )</td>
<td>[de]Σ [tain]Σ</td>
</tr>
<tr>
<td>g.</td>
<td>detention</td>
<td>( \rightarrow de[t^h]ention )</td>
<td>[de]Σ [tention]Σ</td>
</tr>
<tr>
<td>h.</td>
<td>entire</td>
<td>( \rightarrow en[t^h]ire )</td>
<td>[en]Σ [tire]Σ</td>
</tr>
<tr>
<td>i.</td>
<td>curtail</td>
<td>( \rightarrow cur[t^h]ail )</td>
<td>[cur]Σ [tail]Σ</td>
</tr>
<tr>
<td>j.</td>
<td>satire</td>
<td>( \rightarrow sa[t^h]ire )</td>
<td>[sa]Σ [tire]Σ</td>
</tr>
<tr>
<td>k.</td>
<td>reptile</td>
<td>( \rightarrow rep[t^h]ile )</td>
<td>[rep]Σ [tile]Σ</td>
</tr>
<tr>
<td>l.</td>
<td>infantile</td>
<td>( \rightarrow infan[t^h]ile )</td>
<td>[infan]Σ [tile]Σ</td>
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</tbody>
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(5)  
a. sting \rightarrow *s[t^{b}]\text{ling} \quad [\text{sting}]\Sigma
b. abstain \rightarrow *\text{abs}[t^{b}]\text{ain} \quad [\text{ab}]\Sigma \quad [\text{stain}]\Sigma
c. austers \rightarrow *\text{aus}[t^{b}]\text{ere} \quad [\text{au}]\Sigma \quad [\text{stere}]\Sigma
d. after \rightarrow *\text{aff}[t^{b}]\text{er} \quad [\text{after}]\Sigma
e. alter \rightarrow *\text{al}[t^{b}]\text{er} \quad [\text{alter}]\Sigma
f. satyr \rightarrow *\text{sa}[t^{b}]\text{yr} \quad [\text{satyr}]\Sigma
g. shatter \rightarrow *\text{sha}[t^{b}]\text{er} \quad [\text{shatter}]\Sigma
h. hospital \rightarrow *\text{hospit}[t^{b}]\text{al} \quad [\text{hospital}]\Sigma
i. night owl \rightarrow *\text{night}[t^{b}]\text{ o} \quad \text{owl} \quad [\text{night}]\Sigma \quad [\text{owl}]\Sigma
j. flat iron \rightarrow *\text{flat}[t^{b}]\text{ iron} \quad [\text{flat}]\Sigma \quad [\text{iron}]\Sigma

The metrical foot in English is figured from the right edge of word, and (usually) consists of a stressed syllable along with any following unstressed syllables; hospital constitutes but a single foot while infantile, with two stressed syllables, contains two feet. The principles of prosodic phonology require that all syllables be parsed into metrical constituents, though, even unstressed syllables left stranded by the basic footing procedures; hence a single word–initial unstressed syllable will also be incorporated into a metrical foot, albeit a ‘degenerate’ one, as in the first syllable of bipedal forms like terrain and abstain. The unified generalization which characterizes the distribution of English aspiration then emerges as follows:

(6) Voiceless stops are aspirated in foot–initial position, elsewhere they are not.

Accordingly, /t/ is aspirated in the foot–initial positions of the words in (4), but not in the foot–medial or foot–final positions of the words in (5).
Kiparsky (1979) holds that the 'devoicing' of sonorant consonants exemplified in (2) is also constrained by the metrical foot, and that this takes place within \( I_slip \) \([a\text{ys}][\text{lip}]\Sigma\), \( eye \ slip \) \([a\text{y}][\text{slip}]\Sigma\) but not between feet \( ice \ lip \) \([a\text{y}][\text{lip}]\Sigma\). But devoicing does not occur in the foot-internal environments of words like \( Atlas \) (Jensen 1983:130), \( apricot \), \( acclimate \), \( acrimony \), etc., all of which are monopausal and internal to which, therefore, voiceless stops would not be aspirated, either, by the terms of (6). The characterization of 'sonorant devoicing' as spreading of the feature [spread glottis], as per the preceding section, accounts for the absence of devoicing in these forms without stipulation, revealing that sonorant devoicing occurs just after those stops which would be aspirated if they were followed by a vowel rather than a (now voiceless) sonorant consonant. This is because sonorant devoicing and stop aspiration are instantiations of the same phenomenon, the implementation of [spread glottis] in—as will be argued presently—a metrically prominent syllable.6)

By the proposals advanced here, then, no rule to the specific effect of (6) need be posited since aspiration is merely the phonetic implementation of a [spread glottis] phonological specification. That is, 'aspiration' is inherent in the voiceless obstruents of English because the [spread glottis] feature forms part of their basic representation. This gesture is present even in foot-initial /s/-clusters, as in (5a–c), but there its effects do not include aspiration because, following Kim's (1970) origial observation, the open glottis has already begun to close during the articulation of the stop in the cluster, achieving an adducted state of the vocal folds by the time of

6) The (partial) sonorant devoicing observed in \( I_slip \) \([a\text{ys}][\text{lip}]\Sigma\) is then due to some metrical prominence in the second syllable, which retains the full vowel [I]; but sonorants following foot-medial voiceless fricatives do not devoice if the syllable containing the sonorant has no prosodic prominence (and the unstressed vowel is schwa), e.g., \( Kestler \) \([k^\theta][\text{es}][\text{la}]\).
closure release. In (5d), similarly, there is at most one [spread glottis] specification to be shared between the two segments /f/ and /t/, as per the observation in (3) (as well as the OCP), with the result that 'aspiration' is again masked by the closure phase of the cluster. In the stops of the words in (5e–j), on the other hand, the glottis will have narrowed considerably since no aspiration occurs, and there is no other obstruent segment with which a [spread glottis] specification could be shared. Here, among voiceless stops medial in the foot, the glottis appears no longer to be sufficiently spread to induce an aspiration effect.

This reduction in glottal width is reminiscent of the glottal narrowing which takes place among the lax obstruents in intervocalic contexts in Korean. In this language, as in English, the fricative /s/ is articulated with an open glottis throughout in word-initial position, but the phonemically lax stops /p t c k/ are produced word-initially with only slightly abducted vocal folds, i.e., they are moderately aspirated. In word-medial position, the space between the vocal folds is reduced in all lax obstruents, to about the same degree for both the fricative and the stop (cf. Iverson 1983b). With its glottis more widely open to begin with, this narrowing action results in a less 'forceful', or somewhat breathy, fricative since glottal airflow has been reduced appreciably; yet the fricative remains voiceless because the vocal folds still do not come into contact. The lax stops, on the other hand, become voiced since the same degree of narrowing for them does result in approximation of the vocal folds, i.e., in closing of the glottis. In English, it would appear a similar 'laxing' of the voiceless stops characterizes phonation in foot-medial position, both because aspiration is absent there and, in American dialects, /t/ is subject to voicing (flapping). In

7) Such sharing of a single laryngeal gesture even in medial clusters of voiceless obstruents has been reported by Munhall & Löfqvist (1992), and is also the basis proposed by Cooper (1994) for lack of aspiration in words like after.
elaborating their general paradigm for 'phonetic knowledge', in fact, Kingston & Diehl (1994: 431) summarize the recent research on glottal abduction relative to word position in English phonetics in exactly these terms:

"Glottal opening is simply smaller intervocally than initially and before unstressed than before stressed vowels, and this smaller opening leads to shorter voicing lags (VOTs) and thus less aspiration."

They go on to underscore the foot-based character of English aspiration, pointing out its sensitivity to both word position and stress:

"...intervocalic stops have much longer VOTs before a stressed vowel than before an unstressed vowel, while [word-initial] stops have relatively long VOTs regardless of the stress of the following vowel. This result is surprising given that initial position as well as the following stress increases the glottis opening's size and duration."

In place of the conventional provision of the feature [spread glottis] just to foot-initial stops, however, we suppose that the feature is present to begin with English and most other Germanic languages. But this feature is implemented in its fullest realization only in foot-initial position—elsewhere the vocal fold abduction associated with a [spread glottis] specification is of such lesser degree that aspiration either does not occur at all or is sharply reduced:

8) Similarly, in Kiparsky’s (1979) account of English aspiration foot-internal voiceless stops become [+lax] after nonconsonantal segments: [-lax] stops then acquire the feature [+aspiration], though this would need to be restricted to foot-initial position since the /t/ in sting, for example, is neither lax nor aspirated.
(7) [spread glottis] is implemented with fully abducted vocal folds only in foot-initial position.

Accordingly, /t/ in the words of (4) exhibits its [spread glottis] property maximally because in those forms it is in the onset of a foot-initial syllable. In the words of (5a–c), [spread glottis] is also realized to full extent in a foot-initial onset, but there it is part of a cluster of obstruents and so is interpreted as per (3), i.e., the feature is shared, hence aspiration is absent on release of the stop, as described above. Elsewhere, as in the remaining words of (5), the /t/ is not part of the onset of a foot-initial syllable, and [spread glottis], while still present in the segmental representation, consequently is not implemented in its strongest, aspiration-inducing form.\(^9\)

The manifestation of phonological structure in fullest form precisely in prosodically prominent positions (word-initial, beginning of a stressed syllable) accords entirely with the general principles and preference laws for syllable structure developed by Vennemann (1988), specifically, the 'Head Law':

A syllable head is the more preferred: (a) the closer the number of speech sounds in the head is to one, (b) the greater the Consonantal Strength value of its onset, and (c) the more sharply the Consonantal Strength drops from the onset toward the Consonantal Strength of the following syllable nucleus. (1988: 13–14)

We suggest, however, that the realization of [spread glottis] in English in

\(^9\) In (5d) and (5h), the stop forms a heterosyllabic cluster with a preceding strident fricative, a segment type which may retain a more substantially open glottis throughout its articulation in order to maintain turbulent airflow (Kingston 1990), in which case absence of aspiration in the stop follows the familiar pattern of other fricative plus stop clusters.
even more straightforward—yet also more variable—than is represented in (7). In particular, though aspiration in English is not contrastive, there do seem to be (as in Korean) multiple degrees of aspiration, or varying extents of glottal width, among the voiceless stop articulations in this language. By the terms of (7), aspiration occurs in the prosodically doubly prominent position of the onset of a syllable at the beginning of a foot, where a stop is both syllable-initial and foot-initial; but as has often been observed (cf. especially Kingston & Diehl 1994:431), aspiration is strongest (or longest, or noisiest) in this position if that is also the syllable on which primary stress falls. That is, there is greater word-initial aspiration in the primary-stress forms of (4a–c) than in the unstressed syllable of (4d–e), while the primary-stress word-medial aspiration in (4f–i) is about as strong as the primary-stress word-initial aspiration in (4a–c); similarly, the weaker word-initial aspiration in the unstressed syllable of (4d–c) is like that in the secondarily stressed word-medial forms of (4j–m). If we assume three degrees of aspiration—strong, weak, and none—and thus three degrees of glottal width, as per Kim (1970), then these distinctions can be read directly off a ‘metrical grid’ of the sort employed, for example, by Halle & Vergnaud (1987). Here the metrical prominence of a syllable is ranked (0, 1, 2) according to how many asterisks it is accorded in the grid (1, 2, 3):

(8) 2(Word) * * * * * * *  
1(Foot) * * * * * * * *  
0(Syllable) * * * * * * * *  


The metrical prominence of the syllable containing /t/ in its onset is greater in *tuna* than in *terrain*, and so is the strength of the /t/′s aspiration; similarly, the metrical prominence of the word-medial syllable containing onset /t/ is greater in *entire* than in *satire*, as is the degree of aspiration.
of /t/. Outside of the syllable onset (night owl), or in the onset of a syllable with the lowest degree of metrical prominence (hospital), aspiration is at its lowest level, i.e., zero, though phonologically the stop itself remains characterized by the feature [spread glottis].

The phonetic realization of [spread glottis] in English is thus more accurately described by the statement in (9), where a syllable's 'metrical prominence' correlates with the number of asterisks in metrical grid representation. The degree of glottal opening upon closure release, and so the extent of aspiration, then varies directly with the level of metrical prominence (1 = moderately open glottis, 2 = fully open glottis):

(9) Vocal fold abduction in syllable onsets is enhanced in relation to metrical prominence.

In the onset of a primary-stressed syllable, glottal width will be greater than in the onset of a secondary-stressed one, and greater still than in the onset of an unstressed syllable. In the syllable coda, irrespective of metrical prominence, [spread glottis] also will be implemented weakly since it is not structured in the onset. On the assumption that this feature is a basic property of voiceless obstruents in English, then, particularly of stops, there is no requirement (or justification) in the language for a rule of aspiration per se. Rather, the extent of aspiration in voiceless stops varies according to the metrical prominence of the syllables they initiate, as per the principle in (9), and according to whether the [spread glottis] feature is independent or shared, as per the principle in (3).10)

10) Heterosyllabically, the two principles may intersect, so that [spread glottis] is shared between a coda stop and a metrical prominently onset, as in (a[kʰ]livity): aspiration still accrues to the onset stop, presumably because the short duration of the coda stop consumes only a small portion of the laryngeal gesture (cf. intervocalic clusters of phonetically longer fricative followed by unaspirated stop,
5. Germanic and other parallels.

Other Germanic languages exhibit similar variation in the degree of aspiration. In instrumental studies of Danish, Hutters (1985:16–18) has confirmed that, as expected, the duration of aspiration decreases along with the duration of oral closure in faster speech; however, the extent of aspiration also correlates positively with degree of stress-syllables with main, reduced, or weak stress are initiated by voiceless stops with, respectively, heavy, light, or (nearly) zero aspiration. In an extensive impressionistic analysis of German, Lotzmann (1975) found essentially the same distribution, with heavy (‘positive’), light (‘indifferent’), and zero (‘negative’) degree of aspiration. Similarly, Keating (1984) showed that aspiration in German was stronger for syllables with main stress than with secondary, and that voiceless stops beginning word-initial stressed syllables were more heavily aspirated than those beginning word-medial syllables. She also recorded a three-way, stress-sensitive split in degree of aspiration in English. The most recent experimental work on English also verifies the metrical variation of aspiration as exemplified in (8). In experiments with nonsense disyllabic words, Cooper (1994) shows statistically significant positive correlations between extent of aspiration and degree of stress in word-medial environments, and also finds word-initial voiceless stops to be substantially aspirated even in the absence of stress. Cooper (1994:21) concludes that "it appears that these I[ndices] O[f] A[spiration] are distributed differently in different syllable positions and that stress, or perhaps some other prosodic variables, also contribute to the contextual variation of the IOAs."  

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11) Length of closure in aspirated stops is inversely proportional to the duration of aspiration, e.g., [p] has the longest closure and shortest aspiration while [t] has the shortest closure and longest aspiration in Danish.
12) VOT is another IOA. Variation in VOT is generally a function of glottal width and other physiological/dynamic factors, but in Icelandic (among other Scandinavian
The representation of English voiceless stops in terms of [spread glottis] also ties in closely with the 'lenis-fortis' analysis of obstruent manner distinctions promulgated especially by European phoneticians working on the Germanic languages (cf. Kolher 1984, Hutters 1985, others). Thus, Kohler (1984:153) takes aspiration and voicing merely to be "...glottal reinforcements of the fortis and lenis actions of the oral valve..." concluding as well that there is a close connection between 'glottal opening' and the processes of both sonorant devoicing and stop aspiration (1984:158). A fairly complex system of gestures and correlates is employed in defining the composite characteristics of fortis vs. lenis articulation, but we understand the fature [spread glottis] to be primary, at least phonologically, for the Germanic voiceless obstruents phonemes under discussion here. In fact, Kohler (1984: 160-161) expresses a similar view in explaining the anatomical basis for fortis, or 'power', articulation:

An abduction of the vocal folds can also lead to a higher power because, with \( \text{volume} \times \text{pressure} = \text{power} \), a rise in airflow at a constant subglottal pressure increases the air-stream power. Thus the dynamics of the supraglottal articulators... and/or the air-stream, regulated by the glottal valve, imply greater effort in the fortis obstruent through higher power.

In our terms, broadly abducted vocal folds equate with a specification of [spread glottis], a primary gesture from which 'fortis' articulation then derives.

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varieties, including Faroese), it appears to be controlled independently. Thus a single [spread glottis] gesture results either in preaspiration (from underlying geminate stops) or postaspiration (underlying singletons); in sonorant consonant plus voiceless stop clusters, however, if the sonorant devoices (as is usual in casual speech) then the stop is not aspirated, e.g. vanta 'lack' [vanta], not *[vænta], and if the sonorant is voiced then the stop is aspirated: [vænta], not *[vanta] (cf. Thrainsson 1978, Kingston 1990). These facts are easily accommodated if just a single instance of [spread glottis] is assigned to the cluster, varying in rate or style of speech as to the time at which it is initiated.
We follow Kohler as well in ascribing the cluster of fortis properties to the basic articulation mode in the Germanic languages. This means, specifically, that the two-way laryngeal contrast among the obstruents of English (German, Danish, etc.) is encoded as a fortis versus lenis distinction, or spread versus nonspread glottis, not as merely voiceless versus voiced. On the other hand, we represent the two-way laryngeal contrast in languages like Spanish (or Polish—cf. Keating, Mikos & Ganong 1981:1268) by means of the feature [voice] rather than [spread glottis], the result of which for phonetic implementation is that voiced stops are voiced even during the closure phase, while voiceless ones are simply voiceless, not also aspirated. This familiar typological difference between the Germanic (weakly or passively voiced ‘voiced’ stops, aspirated voiceless stops) and the Romance languages (thoroughly voiced voiced stops, unaspirated voiceless stops) is thus made to be quite fundamental, a part of the phonological representation itself. The idea has merit beyond the level of comparative phonetics, however.

For example, if we go along with the suggestions put forth in ‘radical’ underspecification theory (Kiparsky 1982), English voiceless, fortis obstruents would be represented with the feature [spread glottis], but voiced, lenis obstruents would be underspecified for laryngeal features, i.e., not specified at all, which is tantamount to claiming that the voiceless obstruents of English are ‘marked’ and the voiced ones ‘unmarked’. This is a fruitful result on a number of counts. Irregular monosegmental inflectional suffixes, as in the preterite form meant (cf. mean with long vowel), are voiceless in English, but regular suffixes are voiced (weaned, creamed, etc.). Under the fortis articulation proposal, morphological markedness matches up directly with markedness in the phonology, because the irregular or marked inflections are also the phonologically specified ones ([spread glottis]), while the regular, unmarked inflections are phonologically unmarked, i.e., underspecified, for laryngeal features([ ])
It is also the case that voicelessness in the form of [spread glottis] is shared in consonant clusters in English (cf. the principle in (3)), hence the plural form *cats terminates in an [s] rather than in a [z] (cf. *boys, *girls, etc.). Interpreted in conventional assimilatory terms as feature spread, this means that the voiceless quality of the stem-final /t/ in cat has to extend into the suffix /z/ in order to make it into [s], which is possible only if voicelessness is specified to begin with. The feature which spreads cannot be [−voice] if [voice] is construed as ‘privative’, as per Itô & Mester (1989), however, because then only voiced values can be represented phonologically. Indeed, it does appear that [voice] (rather than absence of [spread glottis]) is the correct phonological representation of the laryngeal gesture for vocal fold vibration in some systems, in view of the demonstration Ito & Mester provide of the Lyman’s Law phenomenon in ‘rendaku’ compounding in Japanese. There the otherwise general attachment of the feature [voice] to the initial obstruent in the second element of compounds is interrupted by the presence of other voiced obstruents (kita+kaze ‘(freezing) north wind’, not *kita+gaze), but [voice] attachment freely passes over sonorant consonants (origami < ori+kami ‘fold paper’) and voiceless obstruents (nekojita ‘aversion to hot food’ < neko+šita ‘cat+tongue’). Taking [voice] to be specified in voiced obstruents, but not in sonorants (where it is predictable) or in voiceless obstruents (where it is absent), will accomodate this pattern of rule-blocking in Japanese. But if [voice] is privative in Japanese, Itô & Mester reason, so must it be in all language, assuming that the phonological features are universal. This would invalidate any rule which must be defined on the absence of [voice], as progressive assimilatory devoicing has generally been described for English. Hence approaches to assimilation in which devoicing takes place must account for the phenomenon in different terms, generally by appealing to phonological neutralization in syllable codas (German fragt[fRakt] < /fRag+t/ ‘asks’) or to ‘universal tautosyllabic devoicing’ via the principle that voiced obstruents may not lie outside of voiceless ones
in the same syllable (hence English *cats* [kʰæts] < /kæt+z/; cf. especially Cho 1990). If Germanic voiceless obstruents are represented with [spread glottis], on the other hand, then a feature is available for spreading, and assimilatory devoicing (as in English, German, Swedish, Danish) can be characterized directly as what it appears to be, assimilation.13)

Languages like Spanish, Polish, or Japanese, in which voiced stops are voiced throughout while voiceless stops are generally unaspirated, employ the private feature [voice] to distinguish voiced from voiceless obstruents; hence there the feature [voice] is available for assimilatory spread.14) But in (most) Germanic languages, voicing in obstruents is passive, or redundant, and the laryngeal manner distinction in obstruents is encoded instead via the feature [spread glottis], contrasting unmarked voiced with marked voiceless obstruents. In these languages, 'voicelessness', not voicing, is available for assimilatory spread, hence German *fra[kt], but un*den[kb]ar 'unthinkable', not *unden[gb]ar.15) There is one Germanic language in which the voicing property does spread, however, namely, Dutch (Booij & Rubach 1987), e.g., za[k]en 'pockets' za[gd]oek 'handkerchief' etc.16)

13) Icelandic follows this pattern as well, with prototypical representation of [spread glottis] throughout the obstruent system: the stop series written as voiced is in fact voiceless unaspirated (sometimes called 'lenis') [p, t, k], and the traditional voiceless stops are aspirated even in codas and in unstressed syllables in some dialects ([pʰ, tʰ, kʰ]) (Thráinsson 1994).

14) For languages that employ [voice] rather than [spread glottis], we follow Cho (1990) in characterizing regressive assimilation to voicelessness in obstruent clusters in terms of the delinking (or underparsing) of [voice] in position before another obstruent: thus /g+t→[kt] via delinking, /k+d→[gd] via spread (and, with vacuous effect, /g+d→[gd] via both delinking and spread).

15) In normal spoken German (Umgangssprache), the latter word is also pronounced with a voiceless cluster, although the morpheme-initial /b/ retains secondary lenis characteristics: *unden[kb]ar* (cf. Ramers & Vater 1991:92, Kloke 1982). Such devoicing, not previously well-motivated to our knowledge, falls out automatically as phonetic implementation of the gesture [spread glottis] spilling over from the phonemic /k/ into the adjoining segment.
We take it as significant confirmation of the approach to obstruent representation outlined here that Dutch differs from the other Germanic languages also in the phonetic nature of its obstruents, having Romance-like voiced contrast with unaspirated voiceless stops (Lisker & Abramson 1964). Thus Dutch is phonetically in the camp of languages in which [voice] rather than [spread glottis] is the feature appropriate to phonological representation, and in Dutch (along with its close relative Afrikaans and Yiddish), unlike in other Germanic languages, voicing spreads from one obstruent to another.17

6. Historical implications: the exceptions to Grimm’s Law.

The assumption of [spread glottis] as a contrastive feature in Germanic has important diachronic consequences as well. In particular, it is well-known that the shift of Indo-European voiceless stops to Germanic voiceless fricatives was blocked by an immediately preceding fricative, without regard to whether that fricative was inherited or itself came about as a product of the application of Grimm’s Law, as illustrated in (10-12) (following Lehmann 1986).

16) Dutch also appears to assimilate voiced fricatives to voiceless regressively, as in *tre[kl]+uogel > tre[kt]ogel ’migrant’ (Booij & Rubach 1987). Following Cho (1990), this would be the result of a neutralization that delinks [voice] in fricatives following a syllable-final obstruent. De Schutter (1994:448, 451), however, reports that many Dutch speakers devoice fricatives in word-initial position generally, irrespective of assimilatory considerations (and some varieties—selected northern dialects and Surinam Dutch—devoice fricatives in all environments). On the apparent mismatch between the presence of phonetic voicing and judgements of voicing by native speakers, see also Slis (1986) and van den Berg (1988).

17) Both Dutch and German ’devoice’ syllable-final obstruents. We take this to be a prosodically determined phenomenon to the effect that laryngeal features are not licensed to occur in the syllable coda, whether [voice] (Dutch) or [spread glottis] (German). Obstruents without phonological specification for laryngeal features are then interpreted phonetically as voiceless, generally without aspiration.
(10) Shifted: p, t, k → f, θ, x

IE *pötér → Old Icelandic faðar 'father'
IE *pêlu → Gothic fulfil 'very, much'
IE *tak-e → Gothic kahan 'to be silent'
IE *tewtâ → Old Icelandic bjóð 'people'
IE *kap- → Gothic hafjan 'to lift'
IE *kai-lo → Gothic hails 'hale, healthy'
IE *deks → Gothic taihwsa 'right'

(11) Unshifted: p, t, k in /s/-clusters

IE *(s)pyaw- → Gothic speiwan '(to)spit'
IE *(s)ter- → Gothic stairno 'star'
IE *(s)kel- → Gothic skulan 'to owe'

nwIE *peyskus- → Gothic fisks 'fish'
IE *esti → Gothic ists 'is' (3rd sg.)

(12) Unshifted: t in double-stop clusters (-pt- → -ft-, -kt- → -xt-)\(^{10}\)

nwIE *kap-to- → Gothic hafts 'captured, prisoner'
IE *skap-t- → Old English sceapf 'shaft, pole'
IE *nak't- → Gothic nahts 'night'
IE *oktôw- → Gothic ahtau 'eight'

The 'exceptions' in (11) and (12) have been the subject of considerable speculation. Almost all traditional accounts tie the fricativization element of the shift exemplified in (10) to aspiration: "Again and again, a series of aspirated voiceless stops has been assumed as an intermediate stage in the shift of the voiceless stops" (1976:218).\(^{19}\) Unshifted forms then reflect

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18) We leave aside here the broader Northwest Indo-European development of *-tt- to *-ss- throughout Celtic, Germanic and Italic, as well as to *-st- in a number of other daughters. See Streitberg (1963:115-116), Prokosch (1938:85) and Szemerényi (1989:108-109) for general discussions of this development in an areal and general Indo-European context.

phonetically unaspirated stops in the proto-language, parallel to the lack of aspiration among stops in /s/-clusters in the various daughters (cf. e.g., Grammont 1933). However, this approach implies that various shifted cluster in Germanic forms like Gothic ahtau ‘eight’ arose from IE *okto via[kht]. With aspiration in the first segment rather than in the second, intervocalic clusters like these seem highly implausible phonetically, and conflict in any case with the general assimilatory and neutralization processes operating in Indo-European, including Bartholomae’s Law, which shifts ‘aspiration’ to the end of the cluster (see below). Variants of the aspiration theory include the Brugmann & Delbrück (1930:699) proposal that the fricativization of the first stops in stop*stop clusters may have been a very early phenomenon, well prior to the actual sound shift, a view taken up by Streitberg (1963:115) but which has not found general favor since.20 Others, such as Keller (1978:86), suggest vaguely that these arose ‘presumably because there was neutralization and subsequent reassignment’. Even some attempts at basic observation prove inadequate: Meyer (1894) proposed a rule prohibiting sequences of two fricatives in Proto-Germanic, which naturally fails on examples such as Gothic taihswa, from Proto-Indo-European *deks-.

The most recent account to rely on aspiration as a trigger for Grimm’s Law spirantization is the proposal by Garrett & Hale (1993) that *okto- would have syllabified as o.kto- because kt- was a legal word-initial cluster in Proto-Indo-European. If aspiration accrued only to syllable-initial stops, the fricativization of just the /k/ in /kt/ would then be explained on the assumption that all and only aspirated stops underwent the shift. This kind of syllabification is very unlikely, however, particularly for Indo-European and Germanic in view of Vennemann’s (1988:43-44)

20) The suggestion is based on certain parallels in other branches of Indo-European, including developments like Old Irish recht ‘law’ < *-kt.
demostration that in these families "Internuclear clusters of two are heterosyllabic after short vowels." And the idea that the existence of word-initial clusters should imply their same syllabification word-medially is greatly weakened by the work of Treiman, Gross, & Cwikiel Glavin (1992), who show that allowable English word-initial clusters like sp- are consistently not interpreted as tautosyllabic medially, but rather split between coda and onset. That is, the legal medial syllable onsets in English constitute a proper subset of the word-initial possibilities, just as the [-ksθs]in 'sixths' is possible word-finally but not in word-medial codas.

We too postulate that fricativization under Grimm's Law was related to 'aspiration', but only in the sense that the shift took place whenever the old stop was articulated with a spread glottis, as voiceless stops generally still are in the modern Germanic languages, aside from Dutch. Again in parallel to the modern languages, we further suppose that obstructant clusters shared a single laryngeal gesture (as described above in section 2), with peak glottal width occurring toward the end of the first obstructant narrowing to the point of closure during the course of the second obstructant. A phonetic prerequisite for the shift of voiceless stops to fricatives then was a substantially open glottis, present in the articulation of singleton voiceless stops, or in stops which formed the first (but not the second) half of a stop cluster. Thus the [spread glottis] specification did not necessarily result in aspiration; in particular, the [k] in a [kt] cluster need not have been aspirated at all (indeed, could not have been if, as in English today, it typically was not released in that position; cf. active [æk^tiv], etc.).21 The

21) We surmise that Indo-European did not evince clusters of the form [ktb] as found in activity, where metrical prominence evokes aspiration in the second element. This view conforms to the accentual typology developed by van Coetsem, Hendricks & McCormick (1981), who distinguish between 'non-dominating' and 'dominating' systems, the former showing no accent-related reductions, the latter
[k] in *okto (unremarkably syllabified as *ok.to) shifted, in other words, because it was produced with an open glottis, but the [t] did not, because it was produced with a narrow(ing) glottis.\textsuperscript{22}

The present analysis also brings the fricativization element of Grimm’s Law into conformity with other aspects of Indo-European phonology. The regressive voicing assimilation exemplified in (13) and (15) indicates that intermorphemic clusters in the proto-language also had shared laryngeal properties, presumably involving only a single glottal gesture even heterosyllabically, and (14) illustrates that the process remained morphophonemically active into some of the attested languages (Szemerényi 1989:108).

(13) IE *yeug+to Sanskrit yuk-tá ‘joined’ < ‘to tie, bind’
     Greek zeuk-tós ‘joined’
     *weid+to Sanskrit vittar-‘seen, known’, via *wid-to < ‘to see, know’

(14) Latin rego ‘I choose’ vs. rectus ‘gloss’
     lego ‘I choose’ vs. lectus ‘gloss’ (cf. Lachmann’s Law’)

(15) IE *sed-‘sit’: *ni+sd+os > *nizdos ‘nest’
     *pad-‘foot’: Avestan fra-bda- ‘fore part of the foot’

In most Indo-European daughters, the same sharing of laryngeal structure also applies to contact between reflexes of a traditional ‘voiced aspirate’ and a voiceless stop (e.g., *legh-‘to lie’ appears without aspiration in Greek léktron ‘bed’ *lekh-tron, etc.). But in Indic, the only family in

\textsuperscript{22} The only previous observation close to this is the intriguing remark by Prokosch (1938:60), who suggests that shift in double stop clusters did not occur “apparently because the surplus expiration was absorbed by” the preceding fricative.
which the voiced aspirate articulation type was retained, an apparently progressive assimilation known as Bartholomae’s Law took place, whereby sequences of voiced aspirate plus voiceless stop became simple voiced stop plus voiced aspirate. This too reflects the sharing of laryngeal features within a cluster, of the gestures for both voicing and aspiration (data from Szemerényi 1989:106–107):23)

(16) *bheudh + ta → Sanskrit buddha ‘the awakened one’
*labh + ta → Sanskrit labdhā ‘grasped’(adj.)
*augh + ta → Avestan augštā ‘he said’

Voiced aspirates are actually murmured or breathy stops, characterized in the Halle & Stevens (1971) feature system by the property of [slack vocal folds] (or simply [voice], as we shall refer to it) coordinated simultaneously with a specification for [spread glottis]. This results in a glottal configuration quite different from the [spread glottis] gesture in voiceless sounds, because in murmur the vocal folds are held in approximation throughout the anterior extent of the glottis, vibrating in order to produce voicing, but they are moderately spread at the posterior portion, held apart by the arytenoid cartilages in order to maintain the relatively turbulent airflow which is characteristic of aspiration (Ladefoged 1993). Invoiced aspirates, in other words, the feature of [voice] combines with [spread glottis] to form a laryngeal state distinct from either of these two specifications alone, resulting in the breathy kind of voicing known as murmur. The sharing in clusters of this special voicing (in the Indo-European

23) The feature sharing analysis also conforms to the view that Bartholomae’s Law was a two-stage process of complete laryngeal assimilation which later comes to have murmur realized only on the second stop, viz., /bh-t/-+ /bdh/-+ /bdh/. See Collinge (1985:8–10) for a review of such proposals, including Schindler’s (1976) rule for Proto-Indo-Iranian, which has /dht, tdh, ddh/ all becoming /dhdh/.
daughters which retained it) gives rise to Bartholomae's Law, which we take to be the phonetic implementation of murmur as extended over two obstruents in succession, shared the same way as are other laryngeal gestures in clusters:

(17) "Bartholomae's Law"

\[
\begin{array}{c}
\text{b}^h \\
\text{t} \\
\text{sp gl}^l \\
\text{voice} \\
\end{array}
\quad
\begin{array}{c}
\text{b} \\
\text{d}^h \\
\text{sp gl}^l \\
\text{voice} \\
\end{array}
\]

Extending throughout the cluster, this combination of features results in a distinctive burst of 'voiced aspiration' upon release of the second closure. The implementation of [spread glottis] in combination with [voice] thus differs from the essentially aerodynamic manifestation of [spread glottis] in the absence of any vocal fold vibration: the former, murmur, is a largely steady-state configuration in which the major portion of the glottis is already closed throughout the articulation: the latter, voicelessness or aspiration, progresses over time from a wide open to a closed state of the glottis. ²⁴ But both gesture types were shared between the members of an obstruent cluster, and both the progressive and regressive laryngeal assimilations of Indo-European are instantiations of the same feature—

²⁴ Synchronically, as Davis (1994) has persuasively argued for Hindi, voiced aspirates may not manifest breathy voice per se at all, but the four-way laryngeal contrast is nonetheless phonetically accurately captured with the features [voice] and [spread glottis]. Both aspirate series in Hindi are produced with a relatively wide glottis, though voiceless aspirates show a longer lag before voicing due to greater glottis width, voiced aspirates a shorter lag due to a less spread glottis. Phonetic use of breathy voice then serves to enhance the perceptual saliency of the voiced aspirate series, which will be representationally more marked ([spread glottis, voice]) than either the voiceless aspirates ([spread glottis]), the simple voiced ([voice]), or the voiceless unaspirated series ([ ]).
sharing phenomenon as explains the apparent exceptions to fricativization under Grimm's Law.\textsuperscript{25)}

The present account of aspiration in modern Germanic languages and of the fricativization 'exceptions' to Grimm's Law also provides a motivation for the process by which especially aspirated voiceless stops tend to shift to fricatives. Kohler (1984:164) observes that voiceless aspirated stops generally have a 'weaker and shorter' closure than unaspirated stops (a substantial portion of an aspirated stop's duration is taken up in the release phase, whereas the entirety of an unaspirated stop is contained in the closure). And as Ohala (1990:438) has recently observed, "...the shorter the closure, the more likely it is to be incomplete, thus a spirant..." (cf. also Grammont 1933:167–168). In addition to this articulatory 'weakness' of oral closure as a motivation for their shift to fricatives, it can be observed that the wide glottis of aspirated stops parallels the laryngeal configuration required for strident voiceless fricatives like /s/ (Kingston 1990:427). In Indo-European, where /s/ was the only fricative obstruent, the [spread glottis] gesture presumably would have been particularly salient, and rather easily identified as the primary manner property of the weakly occluded, aspirated stops, thus providing perceptual support as well for their shift to fricatives.

\textsuperscript{25)} Additional evidence for the sharing of laryngeal features in Indo-European lies in the process known as 'Siebs' Law' (Collinge 1985:155–157), which neutralized laryngeal distinctions in initial position following the sole fricative in the system, /s/. Thus, \textit{*s+k-} and \textit{*s+g-} yield \textit{*sk-}, \textit{*s+gh} yields \textit{*sk}: Dutch \textit{stoom} 'steam' vs. \textit{doom} 'steam, fog' etc., Middle High German \textit{schellen} vs. Old High German \textit{gellon} 'to make noise, a racket'. (We leave aside the far less certain non-Germanic instantiations of this rule.)
7. Conclusion.

This paper has argued for the phonological representation of voiceless stops in most Germanic languages via the feature [spread glottis]. Together with the observation that that gesture is shared in obstruent clusters, a simpler understanding emerges of aspiration and sonorant devoicing in English, accounting for a broader range of facts and invoking less machinery in the process. The analysis also relates the varying degrees of aspiration to the independently required weightings of metrical structure, and achieves a rapprochement with the ‘fortis/lenis’ distinction which has recently been advocated for Germanic by several phoneticians. Thus a typology emerges between languages which employ [voice] (Romance, Slavic) and those which employ [spread glottis] (Germanic) in two-way obstruent systems, though in more complex systems, as in Hindi, both features are used contrastively. The diachronic implications of this view are also significant. Based on the reasonable assumption that Proto-Germanic had essentially the same phonetics as most of its daughters, the long-unexplained set of exceptions to Grimm’s Law falls out naturally as a consequence of the [spread glottis] feature having been shared in obstruent clusters; this pattern also fits in with a range of rules or laws pointing toward the sharing of laryngeal features within obstruent in other branches of Indo-European.

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