Voice

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1 Abstract

In this paper, we argue that the contrast in the Germanic languages between stops represented with the symbols < b, d, g > versus < p, t, k > is for [voice] and not [spread glottis], and has been for [voice] throughout the family's history. In constructing this argument, we not only draw on evidence from the diachrony of these sounds within the Germanic languages, but also evidence that phonological features do not have essential phonetic exponents.

2 Introduction

We make two related arguments in this paper, one specific to Germanic and the other quite general. First, stops contrast for [voice] rather than [spread glottis] in nearly all present-day Germanic languages, excepting Icelandic and Faroese, which do contrast stops for [spread glottis], and Swiss German and Bavarian, where there is now a quantity rather than a laryngeal contrast, and [voice] has been the feature distinguishing these stops throughout their history.[1] Second, distinctive features do not have essential phonetic exponents, but instead vary in how they are realized phonetically as a function of context and language. If the distinctive features have no essential phonetic exponents, then inspection of the superficial phonetic properties of a minimally contrasting pair of phonemes in particular contexts cannot determine what feature distinguishes them. We do not therefore present evidence that the phonetic essence of the contrast between /b, d, g/ and /p, t, k/ in these languages is that of [voice] rather than [spread glottis], but instead use their histories, phonotactics, and phonological alternations in making our case. We nonetheless show that distinctive features can still be defined phonetically, because their varying acoustic correlates integrate auditorily to produce similar perceptual effects. The resulting phonetic definitions of distinctive features are of a non-essential kind. We also argue that properties which some have identified as the phonetic essence of the contrast between /b, d, g/ and /p, t, k/ have a prosodic rather than contrastive function.

Who, then, asserts that the contrast is instead [spread glottis]? In a series of papers, Iverson & Salmons (1995, 1999, 2003, 2007) have argued that stops have contrasted for [spread glottis] rather than [voice] since the First Consonant Shift (Grimm's Law) separated the Germanic stops phonologically from their Proto-Indo-European sources. Jessen (1998, 2001), Jessen & Ringen (2002), and Helgason & Ringen (2008) present phonetic evidence regarding the pronunciations of stops in present-day German and Swedish which they ar-

[1] We assume without argument in this paper that the contrasts that concern us are all privative.

gue shows that the German stops contrast for [spread glottis] not [voice], and the Swedish stops contrast for both features.[2] Honeybone's 2002 arguments for "laryngeal realism" rest on the same synchronic and diachronic bases and lead to the same conclusions about the phonological analyses of the Germanic languages throughout their histories. Finally, Vaux & Samuels (2005) have argued that a [spread glottis] contrast is less marked than a [voice] contrast. This paper is intended to refute these arguments, and to bolster arguments first advanced by Keating (1984) and then later by Kingston & Diehl (1994) that these are all [voice] contrasts. The refutation has three parts. We first develop the argument against essential phonetic definitions of distinctive features, we next show that the contrast has been for [voice] throughout the history of Germanic, and finally, we present evidence that the contrast is still for [voice] in the present-day languages (aside from the exceptions mentioned above, Icelandic, Faroese, Swiss German, and Bavarian).

3 Against essentialism

In this section, we argue that distinctive features do not have essential phonetic correlates, and show how they may nonetheless still be defined phonetically, by the perceptual properties produced by integrating their variable acoustic correlates.

3.1 The essentialist position

It is widely agreed that distinctive features have phonetic definitions.[3] There is, however, disagreement about what it means to say that a feature is defined phonetically. One posi-

[2] Recordings we have heard reveal that some Swedish speakers consistently pronounce initial /b, d, g/ as voiceless unaspirated stops.

[3] This position is generally but not universally held. Hjelmslev (1953) is the most well-known exception, but others, most recently Hale & Reiss (2000), have argued that phonological form should be separated completely from phonetic substance.

tion, which we call ‘essentialism’ here, asserts that distinctive feature values map directly onto essential phonetic exponents, which may be articulatory, acoustic, and/or auditory. If the essentialist assertion were correct, then it would always be possible to decide what values a segment has for any distinctive feature by observing its pronunciation, because that segment’s articulation, acoustics, and/or auditory qualities would indicate its phonological specification. This means that if a stop is specified [voice], then it should consistently be pronounced with voicing, and one specified [spread glottis] should be consistently aspirated (see the discussion in Jessen & Ringen (2002) for just such arguments), because in both cases, speakers consistently produce the articulations that have these acoustic consequences. Much of the argumentation in the literature about what the right phonological specification is for a segment relies on the essentialist position being correct, because the arguments are based on observations of this or that aspect of the segment’s pronunciation being consistently produced.[4]

The proponents of the [spread glottis] analysis of the contrast between German or English /p, t, k/ versus /b, d, g/ clearly adopt the essentialist position. Perhaps, Jessen & Ringen (2002) do so most explicitly, as exemplified by the following quotes from early in their paper:

> ‘We take sounds specified as [spread glottis] to be implemented with an active glottal opening gesture ... On the acoustic/auditory level, [spread glottis] in stop production is implemented primarily by aspiration’ [pp. 191-192]

> ‘We take the feature [voice] in stop production to be prototypically implemented with voicing during closure.’ [p. 192]

[4] We use “consistently” here rather than the stronger modifier “invariably” to acknowledge that essential phonetic definitions of distinctive features do not, for example, bar a stop which is specified [voice] from occasionally being pronounced with little or no voicing for aerodynamic reasons, nor one which is specified [spread glottis] from sometimes being pronounced with just brief aspiration. The essentialist account should not be so easily falsified by the speaker’s occasional failures to produce the essential defining phonetic characteristic(s) of the distinctive feature value.

Later on, they point to such facts as the presence of appreciable aspiration following the release of the coronal stop spelled <t> in *(Sie) jagten* [jakt^{h}n̩] '(they) hunted' and the absence of any closure voicing during the coronal stop spelled <d> in *(die) Jagden* [jaktn̩] '(the) huntings' as proof that the <t> is specified [spread glottis] and that the <d> is not specified [voice]. The <d> also is not specified [spread glottis] because its release is not followed by appreciable aspiration, so it differs from the <t> in this context in lacking aspiration, not in being voiced.

3.2 An alternative to essentialism

Kingston & Diehl (1994) was in part intended to be an extended argument against the essentialist position, although it was not explicitly labeled in that way there. They made three related arguments in favor of a non-essentialist and sufficiently abstract definition of [voice] (and other distinctive features).

First, they observed (as have many others) that stops contrasting for [voice] vary substantially in their pronunciation across contexts and languages. Some of the contextual variation in languages such as English is predictable from the speaker's phonetic task in a particular context, for example, whether the speaker has to initiate or maintain voicing. A larger pressure drop across the glottis is required to initiate than maintain voicing, which leads to voiceless unaspirated pronunciations of initial [voice] stops but voiced pronunciations of those that follow sonorants. Other variation is not in any obvious way predictable from the phonetic demands imposed by context; for example, many English speakers pronounce syllable-final voiceless stops with a simultaneous closure of the glottis, not an opening. This closure may be intended to turn voicing off abruptly, but there is nothing about final position in a syllable that requires this gesture rather than glottal opening for this purpose. More telling is the fact that there is no phonetic property that is shared by all variants of English stops specified or unspecified for [voice] that is not also a phonetic correlate of the other category (in some other context). The most important conclusion that Kingston & Diehl drew from these facts is that no context provides better phonetic evidence than any other for deciding which distinctive feature the stops contrast for.

Second, Kingston & Diehl argued that speakers independently control many of the articulations whose acoustic consequences are correlates of the [voice] contrast, rather than producing a single controlled articulation, which automatically produces other articulations. They focused their argument on differences in vocal fold tension, which produce F0 differences on vowels flanking obstruents contrasting for [voice]. These F0 differences have been explained as automatic byproducts of a variety of other, deliberate articulations, for example, lowering the larynx to expand the oral cavity and thereby encourage voicing, or contracting the cricothyroid to stiffen the folds and inhibit voicing, but Kingston & Diehl showed these and other deliberate articulations cannot automatically produce the observed F0 differences as an unintended side effect.

Because these explanations all failed in one way or another, Kingston & Diehl were led to argue that the F0 differences might also be deliberately produced. Whatever the articulation is that produces the F0 differences, it typically covaries with that which produces voicing differences, and both typically covary with that which produces complementary duration differences in the consonant and preceding vowel. If all these articulations are independently controlled, why should they covary as they do? Kingston & Diehl propose that speakers covary them in the observed ways to produce arrays of acoustic properties that integrate perceptually (see section 3.4 for more extensive discussion of perceptual integration). If each of these articulations is controlled and multiple articulations contribute to producing the [voice] contrast, none of them is any better a choice than the others as the principal phonetic correlate of the contrast, and none can be used to define that contrast. This position contrasts sharply not only with that advocated by Iverson & Salmons, Jessen & Ringen, and Vaux & Samuels, but also with the proposal of Halle & Stevens (1971) that what appears to be a [voice] contrast is subsumed under a more general contrast between [stiff] and [slack] vocal folds (and therefore equally against the proposal of Avery & Idsardi (2001) for a dimension they call ‘Glottal Tension’ to replace [voice]).

These two arguments dovetail: neither any context nor any articulation is privileged over the others in defining the contrast phonetically. Rather it is the product of integrating their covarying acoustic consequences that does so (section 3.4).

The third argument was that phonological alternations for [voice] are indifferent to differences between manners of articulation in how it is realized and even whether the laryngeal articulation is distinctive. The laryngeal and covarying oral articulations of voiced obstruents are quite different from those in voiced sonorants, yet both select the same voiced allomorphs of the plural and past tense suffixes in English. More subtly, the [voice] contrast is pronounced differently in fricatives than in stops, yet these differences, too, have no consequences for the selection of plural or past tense allomorphs. In both instances, the natural classes that select the voiceless and voiced allomorphs do not have uniform phonetic realizations, and must therefore be defined with sufficient abstractness to encompass the full variety of their pronunciations and to select the appropriate allomorphs of these suffixes. (See also Hayes (1999) for similar arguments.)

This third argument points to another, more reliable way of determining a segment’s phonological specification, namely, the grouping of that segment with others in diachronic and synchronic phonological patterns. Phonological specification can be determined by such participation in a natural class without assuming that the distinctive feature value that characterizes all members of that class has any essential phonetic exponent. That is, sounds may belong to natural classes even if the essentialist position is incorrect.

We take up in 3.4 below two related problems that immediately arise if no phonetic exponent or exponents are essential properties of a particular phonological contrast, namely, how then does one decide what the contrast is in a particular case and how can one limit the phonetic variety of the realizations of that contrast?

3.3 Re-evaluating the phonetic evidence for a [spread glottis] contrast in German and English

Here, we re-evaluate the phonetic evidence that Jessen & Ringen (2002) use to argue that obstruents in German contrast for [spread glottis] not [voice]. The first is so-called 'passive' voicing (section 3.3.1), the second is the aspiration observed following the release of /p, t, k/ before unstressed vowels in German (section 3.3.2). As an extension of our discussion of the aspiration of /p, t, k/ in German, we also evaluate Iverson & Salmons's proposal that what looks like syllable-final devoicing in German is actually adding a specification for [spread glottis] to unspecified /b, d, g/ in that context, a process they call 'final fortition' (section 3.3.3).

3.3.1 Intervocalic voicing is not passive

Jessen & Ringen (2002) argue that /b, d, g/ are not specified for [voice] because voicing is not actively produced in their pronunciation, but is instead the passive consequence of favorable aerodynamic conditions in the particular contexts where it occurs. We show that on the contrary voicing still requires active maneouvres even when the aerodynamic conditions favor its production.[5]

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[5] Voicing during the constriction is only one of a number of active maneouvres designed to convey the [voice] contrast; another widely used one is the complementary differences in constriction and preceding vowel duration (Slis & Cohen, 1969a,b; Chen, 1970; Kohler & Künzel, 1978; Lisker, 1986). Braunschweiler (1997) argues that the prolongation of vowels before the shorter closures of voiced stops in German must be an actively produced correlate of the [voice] contrast because it is proportionally the same size, roughly 0.2, for phonologically long as short vowels, despite the long vowels lasting twice as long as the short ones. Alternative accounts in which the durations of the constriction and preceding vowel are co-determined by a single articulatory difference, for example, [b, d, g] are produced with a slower closure and swifter release than [p, t, k] (Kohler, 1984), incorrectly predict that the combined duration of the vowel and consonant would be more or less constant, as do accounts in which the vowel is lengthened to compensate for the shortening of the constriction (Port, Al-Ani, & Maeda, 1980). The shortening of a voiced constriction may

Jessen & Ringen (2002) present acoustic data from six speakers which show that /b, d, g/ are usually fully voiced between vowels; other studies (e.g. Wagner, 2002) show that these stops may be pronounced with voicing continuing only through part of the closure. Jessen & Ringen argue that these partially or completely voiced closures should not be taken as evidence that /b, d, g/ are [voice] because this voicing is 'passive'.

> 'Passive voicing means that without the devoicing effect of glottal spreading, stops can be voiced during most or all of closure if they occur in the context of sonorant sounds, even if there are no active voicing gestures (vocal fold slacking, tongue root advancement, etc.) on the part of the speaker (Westbury, 1983; Westbury & Keating, 1986).' [190]

Kingston & Diehl (1994) had argued that voicing was more likely to occur during the closure of [voice][6] stops between vowels because a smaller pressure drop across the glottis is required to maintain than to initiate voicing. Voicing could thus continue more readily into a stop following a vowel (or sonorant) because the transglottal pressure drop needed to produce voicing would be sustained for a longer time than in a stop not following a voiced segment.

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itself be an active maneouvre, intended to ensure that however long voicing lasts, it continues through most if it not all of the constriction (Ohala, 1983). There is furthermore no physiological reason why the preceding vowel should be longer before a voiced obstruent, and there are cases where it is not (Mitleb, 1984; Keating, 1985). Instead, prolonging the vowel at least adds another correlate to the [voice] contrast, if it does not also exaggerate the perceived shortness of the following constriction (Kluender, Diehl, & Wright, 1988, but cf. Fowler, 1992).

[6] What we call here "[voice]" was called "[+voice]" by Kingston & Diehl, and their [-voice] is replaced by the lack of specification for [voice]. None of their arguments are changed by interpreting this contrast as privative rather than binary.

Kingston & Diehl did not, however, view the continuation of voicing into a post-vocalic stop as 'passive' in the same sense as Jessen & Ringen do.[7] Indeed, there is evidence that speakers do make the active voicing gestures that Jessen & Ringen claim are unnecessary to sustain voicing in this context. Contrary to Jessen & Ringen's summary of what Westbury (1983) reported, his results show that, relative to /p, t, k/, the tongue root is advanced and the larynx lowered in intervocalic /b, d, g/, and that the tongue dorsum is also lowered in /b, d/ – the tongue dorsum obviously cannot be lowered in /g/ as well because it must be raised to the palate to make the closure in velar stops. Westbury's estimates of the combined effects of these active maneouvres also show that the volume of the oral cavity increases over the course of the stop closure in the intervocalic /b, d, g/. Furthermore, Bell-Berti & Hirose (1975) show that the levator palatini is more active and the soft palate is raised more in post-sonorant /b/ compared to /p/. These observations demonstrate that voicing is not passive in intervocalic /b, d, g/, but merely aerodynamically less challenging than when these segments do not follow voiced segments.[8] Westbury's and Bell-Berti & Hirose's data were obtained from English speakers, but as allophonic variation in the pronunciation of /b, d, g/ and /p, t, k/ is very similar in the two languages, it is very likely that German speakers

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[7] They did, however, make the unfortunate suggestion (p. 428) that voicing might continue throughout much of an intervocalic [voice] stop's closure through the agency of passive expansion of the oral cavity – the distension of the soft tissues lining the oral cavity, principally, the lip, cheeks, and soft palate, in response to the rise in intraoral air pressure (Ohala & Riordan, 1979). In the same passage, Kingston & Diehl also noted that speakers might actually have to exert themselves to turn voicing off in stops not specified for [voice] because if the folds are already vibrating, they will continue to do so until the glottal area gets much larger than that needed to start voicing (Lindqvist, 1972; Hirose, Niimi, Honda, & Sawashima, 1985). Even if passive expansion of the oral cavity makes voicing easier to maintain and an active maneourve is required to turn voicing off, the evidence reviewed next in the present paper shows that speakers must nonetheless actively expand the oral cavity to produce voicing in [voice] stops in this context rather than relying on passive expansion.

[8] Notice that voicing is not expected on this account in the <d> in *Jagden* because it would have to be initiated after the devoiced <g>preceding it. This context is thus like initial position.

would also have to expand the oral cavity actively to sustain voicing into a stop following a vowel or other sonorant.

If voicing is not passive but instead the product of active cavity expansion,[9] then speakers apparently intend to produce this correlate of the contrast in intervocalic /b, d, g/, and the feature could be [voice] after all. Jessen & Ringen argue that if this were the case, then the tokens of these stops produced without voicing or with only partial voicing by two of their speakers (as well as by the speakers whose speech is described by Wagner, 2002) would have to be actively devoiced. However, partial or even complete devoicing could readily occur if speakers fail to expand the oral cavity enough to keep the rise in intraoral air pressure in check.[10]

There is an additional problem with the proposal that the phonologically unspecified stops are passively voiced: it predicts incorrectly that the unspecified stops /p, t, k/ would be passively voiced intervocalically in Dutch or Bengali. These stops cannot of course be passively voiced in either of these languages as that would neutralize the contrast with [voice] stops, which are pronounced with voicing during the closure in this context in both languages.

Finally, if the stops that are unspecified for [spread glottis] in German and English acquire passive voicing when they follow vowels, why do those that are similarly unspecified for this feature in Icelandic not also do so in this context? Their utter failure to acquire passive

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[9] We do not mean to imply that the continuation of voicing from a preceding sonorant into /b, d, g/ is not aided by *passive* expansion of the oral cavity as the soft tissue portions of the its walls distend in response to rising intraoral air pressure (Ohala & Riordan, 1979). Instead, we have argued that this continuation of voicing can neither be a passive consequence of favorable aerodynamic conditions nor passive expansion alone because speakers actively expand their oral cavities, too, when pronouncing these stops in this context.

[10] Jessen & Ringen's findings that devoicing is more extensive for velar than alveolar stops and for women than men do not appear to have anything to do with whether voicing is passive in intervocalic stops, so we do not discuss them here.

voicing is surprising because, according to Iverson & Salmons (1995), the laryngeal contrast is phonologically the same in all three languages, [spread glottis].

From a non-essentialist perspective, it is not necessary for stops specified as [voice] to actually be voiced by means of an active manoeuvre such as oral cavity expansion. That analysis would simply have been less plausible if speakers never made any effort to produce voicing. The reason for this is that voicing integrates with a variety of other acoustic correlates of [voice] specification into a number of different perceptual properties, so it is a particularly effective correlate of this specification (see section 3.4 for elaboration).

3.3.2 Aspiration of stops before unstressed vowels

In English, /p, t, k/ are often described as being unaspirated word-internally before unstressed vowels (Ladefoged, 2006); however, there is usually some aspiration after their release even in this context (see Table 1). If /p, t, k/ are consistently aspirated, even in such less prominent contexts, then aspiration would appear to be an essential phonetic characteristic of these stops, and would indicate that they are specified [spread glottis] rather than being unspecified for [voice]. Table 1 shows the mean durations of aspiration (= voice onset time or VOT) before unstressed vowels for two English speakers, sorted by place of articulation (data from Cooper, 1991):

Place	ES		KM	
	Internal	Initial	Internal	Initial
p	18	32	28	42
t	48	51	63	66
k	51	63	66	68

Table 1: Mean VOTs (ms) for word-internal (intervocalic) and -initial /p, t, k/ before unstressed vowels, from two adult male English speakers (ES and KM). No measures of variance are provided in the source.

Similar values are reported by Lisker & Abramson (1967).

Table 2 shows comparable German data from Jessen & Ringen (2002) sorted by speaker gender (3 male and 3 female), stop place, and context. Very similar values are reported in other studies of German (see Jessen, 1998, pp. 50-53, for a review, as well as the values reported in his table 3.2, p. 86).

Males	Females	Context and Place
43 (7, *12*)	36 (6, *12*)	ˈV*k*ə
39 (11, *12*)	42 (5, *12*)	ˈV*t*ə
47 (14, *16*)	34 (17, *15*)	ˈVk*t*ən

Table 2: Mean VOTs in ms (standard deviations, *n*s) calculated from Jessen & Ringen's Table I (2002) for three male and three female German speakers at two places of articulation between stressed and unstressed vowels and after [k] and before [ən]. The stop whose VOT is measured is italicized in the list of contexts and places of articulation.

For the two places of articulation, coronal and dorsal, for which we have data from both languages, VOTs are similar word-internally before unstressed vowels, if not longer in English than German, so speakers of the two languages pronounced these stops similarly.[11] The values in Table 2 are still shorter than those reported by Jessen (1998) or for German /p, t, k/ at the beginnings of words, where aspiration lasted on average 74 ms (s.d. = 23 ms), compared to 60 ms (s.d. 18 ms) between vowels (in his 1998 data); see Table 1 for comparable initial data from English.[12] These values show that speakers of both languages

[11] The duration of the delay in voice onset is in any case not a reliable indicator of whether a contrast is for [spread glottis]. Mikuteit & Reetz (2007) show that in Eastern Bengali, the delay is consistently shorter for [spread glottis] stops that are also specified for [voice], e.g. /g^h/, than for those that are unspecified for this feature, e.g. /k^h/. However, they also show that the combined duration of the voicing delay and the ensuing interval of breathy voicing (intervals they refer to as 'after closure time' and 'spread aspiration', respectively) is very similar in both kinds of [spread glottis] consonants, because breathy voicing lasts proportionally longer in stops specified for [voice] than unspecified ones. Notice also that specification for [voice] is not limited to determining the phonetics of the closure interval but also regulates the timing of laryngeal events and their acoustic consequences after the stop release in this language, contrary to what would be expected if the duration of post-release phonetic events was determined entirely by specification for [spread glottis].

[12] Jessen (1998) does not break his data down by place of articulation except for the single speaker, himself,

reduce aspiration in their pronunciation of /p, t, k/ in a context where less is needed to distinguish them from /b, d, g/, and where less is expected because the stop is in the onset of a prosodically less prominent syllable. This reduction suggests that aspiration is not strictly speaking a segmental property, but instead a prosodic one.

Docherty (1992) shows that /b, d, g/ are consistently pronounced without closure voicing in word-initial position by speakers of British English, even when the preceding word ends in a vowel. He only observes voicing consistently in the pronunciation of /b, d, g/ when they are word-internal. These findings indicate that prosody conditions the selection of allophones of both series of stops: at beginning of phonological words, both are voiceless and they differ in aspiration, while inside phonological words, they differ in voicing. That voicing is harder to initiate than maintain explains the distribution of these selected allophones but does not explain the irrelevance of the preceding context in word-initial position.

This prominence- and edge-dependent variation in how much /p, t, k/ are aspirated and whether /b, d, g/ are voiced appears to be an instance of prosodically conditioned variability in the strength of articulations (Fougeron & Keating, 1997; Keating, Cho, Fougeron, & Hsu, 2003; Cho & Keating, 2001; Cho & McQueen, 2005; Cho, McQueen, & Cox, 2007). Articulations are typically stronger at the edges of prosodic constituents, here at the beginnings of feet and phonological words, and weaker inside such constituents. This variation thus appears to be opportunistic allophony, whose purpose is to signal whether a segment is at the edge of versus inside a prosodic constituent and not the realization of some essential phonetic correlate of a contrast. This property of the signal is thus one of a number of pieces of information that the speaker provides the listener about the prosodic constituent structure of the utterance.

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from which he collected transillumination data. His aspiration was consistently longer at the beginnings of words than between vowels and for more posterior than more anterior stops (see his Table A.27, p. 313).

3.3.3 Final fortition

In a very recent paper, Iverson & Salmons (2007) acknowledge that allophonic variation may be prosodically conditioned and may therefore be intended to inform the listener about the prosodic constituent structure of the utterance. However, rather than the variation in aspiration duration just discussed, the phenomenon they treat in this way is the neutralization of the laryngeal contrast between /b, d, g/ and /p, t, k/ syllable-finally in German. Traditionally, this neutralization has been treated as devoicing of /b, d, g/ to [p, t, k], that is, to pronunciations identical to those of /p, t, k/ in this context.[13] In this recent paper, as well as an earlier one (Iverson & Salmons, 1999), Iverson & Salmons argued that this process is not devoicing at all, but instead adding [spread glottis] to the laryngeally unspecified /b, d, g/, a process that they call 'final fortition' – /p, t, k/ are already specified [spread glottis] and remain so syllable-finally. Specification for [spread glottis] is added to /b, d, g/ as well to convey to the listener that the stop is syllable-final, and thus would serve a communicative function similar to that of adding [spread glottis] to word- and foot-initial voiceless stops in English.[14]

Iverson & Salmons present two pieces of synchronic evidence in support of adding [spread glottis] over devoicing, one phonetic and the other phonological. The phonetic evidence is that a number of studies have shown that word-final /b, d, g/ are often audibly released by German speakers, especially when they occur phrase-finally (p. 134).[15] The phonological evidence is the sharp difference between German and Dutch in the behavior of the first

[13] Because it is tangential to the questions that concern us here, we do not take up the question of whether neutralization is incomplete in German (Dinnsen & Charles-Luce, 1984; Charles-Luce, 1985; Fourakis & Iverson, 1984; Port & O'Dell, 1985; Port & Crawford, 1989).

[14] The fact that adding [spread glottis] is neutralizing in German does not bar it from conveying information about prosodic constituency. Smith (2005) documents a variety of neutralizing processes that take place at the edges of prosodic or morphological constituents, whose apparent purpose is to signal where those edges occur in the string and thus the string's prosodic or morphological constituency.

[15] Iverson & Salmons do not specify that this release is voiceless, but it is probably safe to assume that it is.

obstruent in a cluster of obstruents arising across a compound boundary. Table 3 shows that in German, the first obstruent is voiceless regardless of its underlying form or the laryngeal specification of the second obstruent, while in Dutch the first obstruent assimilates to the laryngeal specification of the second, so long as the second is a stop:

	Underlying form	German pronunciation	Dutch pronunciation
a.	[0] [0]	Stadtpark /tp/ > [tp] 'city park'	zitkammer /tk/ > [tk] 'sitting room'
b.	[0] [voice]	Hutband /tb/ > [tb] 'hatband'	eetbaar /tb/ > [db] 'edible'
c.	[voice] [0]	Farbstift /bʃ/ > [pʃ] 'crayon'	zandpapier /dp/ > [tp] 'sand paper'
d.	[voice] [voice]	Handbuch /db/ > [tb] 'handbook'	kasboek /zb/ > [zb] 'cashbook'

Table 3: Exemplary pronunciations of German and Dutch obstruent clusters arising across compound boundaries, for underlying forms in which (a) both obstruents are unspecified [0] for [voice], (b) the first is unspecified and the second specified, (c) the first specified and the second unspecified, and (d) both specified.

In Iverson & Salmons's account, adding [spread glottis] to the first obstruent in German protects it from assimilating to the laryngeal specification of the second obstruent,[16] as happens in Dutch (Table 3b). Assimilation can occur in Dutch because the first obstruent devoices instead of becoming specified for [spread glottis]. As the Dutch stops are uncontroversially specified for [voice] rather than [spread glottis], devoicing leaves the first obstruent unspecified for any laryngeal feature and thus susceptible to regressive spreading of the second obstruent's [voice] specification, if it has one: /t+b/ > [db] (Table 3b) and /z+b/ > sb > [zb] (Table 3d). If the second obstruent has no laryngeal specification, then the first is just devoiced: /d+p/ > [tp], where both [t] and [p] are unspecified for [voice] (Table 3c).

Neither kind of evidence is convincing. First, a stop can be audibly released without

[16] Notice that if the first obstruent assimilated to the laryngeal specification of the second in German, and German obstruents were specified for [spread glottis], then only the output for /d+b/ would differ from what is observed in this language, i.e. unchanged [db] rather than [tb]. If the first obstruent simply devoiced, even the output for this cluster would not differ from what is observed.

being specified [spread glottis]. All that is required is that the glottis be open enough for sufficient air to flow into the oral cavity during the oral closure that intraoral air pressure builds up during the closure. This could be achieved by the smaller opening of a voiceless unaspirated stop, or by the speaker merely relaxing the muscles that adducted the glottis during the preceding vowel, the interarytenoid, thyroarytenoid, and lateral cricoarytenoid, as the force applied to the arytenoid cartilages by the uncontracted posterior cricoarytenoid is sufficient to pull the glottis part way open (Titze & Hunter, 2007).

Second, in Dutch, when the second member of an obstruent cluster is a fricative, both members surface as voiceless. That is, /p+s, p+z, b+s, b+z/ are all pronounced [ps] (Booij, 1995, pp. 58-59, 146-147), with any [voice] specification being lost wherever it appears in clusters with this manner of articulation in second position. This outcome shows that ostensible laryngeal assimilations in obstruent clusters do not all involve spreading the specified feature nor does specification for [voice] protect an obstruent from ostensibly assimilating. These alternations cannot therefore be used to determine whether that feature is [voice] or [spread glottis].

Third, why should the first obstruent in a cluster need to be protected from assimilation in German by adding a specification for a laryngeal feature to it? Is it not enough simply to state that German lacks a laryngeal assimilation rule? Notice that the first obstruent does not assimilate to the laryngeal specification of the second in English either, despite the fact that [spread glottis] is not added to the first obstruent in a cluster across a compound boundary, e.g. the clusters in *Facebook* and *dog trainer* can only be pronounced [sb] and [gt] and not *[zb] and *[kt]. This outcome has to be explicitly barred by Iverson & Salmons because in their account English obstruents contrast for [spread glottis] just like German ones do, and specified features apparently spread automatically from specified to unspecified members of obstruent clusters.

Iverson & Salmons's arguments reflect the determinism inherent in the essentialist conception of the relationship between phonological specification and phonetic realization. In this conception, phonological specification constitutes an instruction to the phonetics, which must implement it invariably. Only in the absence of such specifications and the instructions that they entail is any variation possible. We suggest instead that sounds' behavior is not completely determined by their phonological specification, but also by the language's phonological and phonetic grammars, in this case by the presence or absence of a rule of voicing assimilation (see Kingston & Diehl (1994) for more extensive arguments in support of this alternative).

Given that English obstruents are also argued by Iverson & Salmons to contrast for [spread glottis], it is furthermore surprising that many English speakers produce syllable-final /p, t, k/ with a simultaneous constriction of the glottis, a laryngeal articulation that is at the opposite extreme from spreading the glottis. The glottis is constricted regardless of whether these speakers release these stops audibly. Even more surprising from Iverson & Salmons's perspective is the fact that speakers of French, a language which everyone agrees contrasts its stops for [voice] and not [spread glottis], release both word-final /p, t, k/ and /b, d, g/ very frequently, as distinctive voiceless and voiced vocoids, respectively (Laeufer, 1992). The voiceless vocoids would necessarily be produced with the glottis abducted, a fact which is quite surprising if glottal abduction is an exclusive phonetic correlate of [spread glottis] and unavailable to [voice]. These facts indicate that specifying stops for [spread glottis] need not lead inevitably to their being pronounced in this way everywhere nor that a [spread glottis] specification is a prerequisite for producing an audible release, as English speakers do, and finally that specifying stops for [voice] does not prevent speakers from abducting the glottis in releasing final voiceless stops, as French speakers do.

Finally, Iverson & Salmons (1999, 2007) appeal to Notker der Deutsche's Anlautgesetz or Law of Initials as evidence that Old High German already fortified word-final stops by adding [spread glottis] to them and then spread that specification to following word-initial stops. This appeal rests on a misinterpretation of Notker's orthographic practice (cf. Lahiri & Kraehenmann, 2004) .

Notker used the letters <p>, <k/c> and <b>, <g> in his German translation of Latin in an entirely predictable fashion (Table 4). For word-initial labial and dorsal stops, he wrote <p> and <k/c> when the preceding word ended in an obstruent (Table 4a) but <b> and <g> when it ended in a sonorant (Table 4b) (or at the beginning of an utterance):

a. Following obstruents	b. Following sonorants
táz ter ta**g p**egónda	S**ô b**egónda
ih máge**d p**in	Er**ô b**in
sóli**h p**in	únbesimze**n b**in
er férros**t k**ât	diu súnn**a g**ât

Table 4: Alternating <p> and <b>; <k/c> and <g> in Notker der Deutsche's orthography. The relevant consonant letter and its context are in bold face.

For word-final stops, he always wrote <b> and <g>, e.g. *lîeb* 'love' *hálb* 'half' and *mánig tag* 'many days' (see Lahiri & Kraehenmann, 2004, Table 2, p.4).

For word-initial coronal stops, Notker used the symbols <t> and <d> in a more complex fashion: in some words, these symbols alternated under the same conditions that <p> and <k/c> alternated with <b> and <g> (Table 5), while other words began with a non-alternating <t> (Table 6).

a. Following obstruents	b. Following sonorants
ís**t t**ánne	s**ie d**ánne
sî sí**h t**óh	únd**e d**óh

Table 5: Alternating <t> and <d>.

a. Following obstruents	b. Following sonorants
túro uuár**t t**âte	d**îe t**âte
máni**g t**ág	d**ér t**ág
mines hóubete**s t**óhter	díu áltest**a t**óhter

Table 6: Non-alternating <t>.

Lahiri & Kraehenmann (2004) argue that the alternating spellings at the beginnings of words in Tables 4 and 5 reflect variation in quantity. In this position in the word, <b, d,

g> stand for geminate pronunciations and their <p, t, k> alternants for singleton pronunciations. A stop geminated after a vowel or sonorant because a coda position was unfilled in the preceding syllable, but remained a singleton after an obstruent because that sound filled up the coda position.

For the labial and dorsal stops, this variation was entirely predictable from the stop's preceding context, but for the coronal stops, the quantity difference was contrastive because Old Alemannic <t> had two diachronic sources: alternating <t> or <d>, pronounced [t] or [tt] (Table 5), descends from PG *þ, while non-alternating <t>, always pronounced [tt], descends instead from PG *d (Table 6). The diachronic sources of the alternating labial and dorsal stops are PG *b and *g, respectively. Just as Notker used <b, g> to write final labial and dorsal stops, he also used <d> to write word-final coronal stops that came from PG *þ, while using <t> word-finally as well as -initially for those that came from PG *d. The Old Alemannic (OA) stop phonemes and their sources are thus:

PG		OA	Word-initial spellings and pronunciations			
*b	>	p	<b>	= [pp] after sonorants	<p>	= [p] elsewhere
*g	>	k	<g>	= [kk] after sonorants	<k>	= [k] elsewhere
*þ	>	t	<d>	= [tt] after sonorants	<t>	= [t] elsewhere
*d	>	tt	<t>	= [tt] everywhere		

Table 7: Reflexes of Proto-Germanic [voice] stops and þ in Old Alemannic, as represented in Notker.

At the time Notker was writing, the Second Consonant Shift had replaced PG *p, *t and *k with affricates or geminate fricatives, pf ˜ ff, ts ˜ ss, and kx ˜ xx, depending on their context. This change eliminated any contrast for [voice] between the reflexes of PG *b and *g versus *p and *k, and replaced it with a contrast between stops versus affricates or fricatives. Since a [voice] contrast had been eliminated, the changes that PG *b and *g underwent appear to be devoicing to /p/ and /k/, but are actually changes to singleton stops. The subsequent change of PG *þ to /t/ was simply the loss of a [continuant] specification, and also produced a stop that did not participate in a [voice] contrast.

We would expect PG *d to have undergone the same changes as PG *b and *g, but this sound instead geminated, perhaps so as not to fall together with the /t/ reflex of PG *þ. This development did not, however, introduce a new contrast for quantity. One already existed between vowels where the Second Consonant Shift had eliminated the [voice] contrast from geminate stops, too: PG *pp, *tt, *kk became pf, ts, kx, and the original Germanic *bb, *dd, *gg became pp, tt, kk in Old Alemannic. The /tt/ reflex of *d thus took on length, introduced a quantity contrast with /t/ initially, and fell together with the reflex of PG *dd medially.

Perhaps the strongest support for this account comes from the fact that Notker's non-alternating <t> corresponds a hundred percent with geminate /tt/ in Old Alemannic's modern descendant, Swiss German (Table 8), while his alternating <t> ˜ <d> correspond to Swiss German singleton /t/ (Table 9) as do alternating <p> ˜ <b> and <k/c> ˜ <g> to Swiss German singleton /p/ and /k/ (Table 10).

Swiss German	German	English
ttuə	tun	do
ttɔxtəʀ	Tochter	daughter
ttaːk	Tag	day

Table 8: Geminate reflexes in present-day Swiss German of Old Alemannic /tt/ < Proto-Germanic *d, with German and English cognates.

Swiss German	German	English
tiŋ	Ding	thing
tiəp	Dieb	thief

Table 9: Singleton reflexes in present-day Swiss German of Old Alemannic /t/ < Proto-Germanic *þ, with German and English cognates.

Two problems arise with interpreting Notker's spelling alternation as the spreading of [spread glottis] from a fortified word-final obstruent, as Iverson & Salmons (1999, 2007) propose. First, if word-final obstruents had been fortified, why did Notker use the letters, <b>, <d>, and <g>, to write what would be lenis stops on this analysis? Second, Notker

Swiss German	German	English
puəx	Buch	book
pett	Bett	bed
kɔtt	Gott	god
kaʃt	Gast	guest

Table 10: Singleton reflexes in present-day Swiss German of Old Alemannic /p, k/ < Proto-Germanic *b, *g, with German and English cognates..

invariably used <p> and <k/c> at the beginnings of words when the preceding word ended in an obstruent, regardless of the nature of the obstruent, that is, after obstruents written <b>, <g>, or <d> as well as those written <t>, <s>, or <h>. Why would he use different letters to write the word-final and word-initial stops if the first had been fortified by the addition of [spread glottis], which had then spread to the second (Table 4a)?

3.3.4 Summary

The discussion in the last three sections has shown that neither the synchronic nor diachronic facts in Germanic support an analysis in which the stops contrast for [spread glottis] rather than [voice]. In the next section, we show how distinctive features can be defined phonetically even if they do not have essential phonetic correlates.

3.4 Non-essentialist definitions of distinctive features

The mapping between phonetics and phonology is certainly much more straightforward if distinctive feature values have essential phonetic characteristics, and it is also easier to limit the number of distinctive features and constrain their allophonic variation if distinctive feature values are realized by essential phonetic properties (cf. Kingston & Diehl, 1994). Nonetheless, it is still possible to define distinctive features phonetically, limit their number, and constrain their variation so long as their phonetic correlates integrate perceptually.

If phonological features have essential phonetic exponents, then a segment's phonological specification reliably predicts its pronunciation, and its pronunciation identifies with equal reliability its phonological specification. The virtues of the essentialist position are not limited to its simplicity, however. Essentialism also makes it possible to catalogue the phonetic properties that correspond to each distinctive feature value and to constrain the variability in its phonetic realization across contexts or languages. For example, a stop specified [voice] can be realized with voicing during its closure but not with an elevated F2 at the edge of flanking vowels, while one specified [dorsal] can be realized with an elevated F2 at the edge of flanking vowels but not by voicing during its closure. If we are to maintain that distinctive features are numbered in the dozens rather than the hundreds or thousands, and that these features are universal rather than particular to contexts or languages, then both a catalogue of each feature's phonetic correlates and constraints on variation in a feature's phonetic implementation are necessary. How, then, are we to obtain these necessities if we do not adopt the essentialist position of invariant phonetic exponence?

Kingston & Diehl (1994) propose an answer to this question, which is backed up empirically by perceptual studies reported in Kingston & Diehl (1995) and Kingston, Diehl, Kirk, & Castleman (2008), as well as other studies cited in these papers. These experiments show that listeners integrate the acoustic correlates of articulations that covary in the production of stops that contrast for [voice] into what these authors call 'intermediate perceptual properties' (IPPs). IPPs are intermediate because they arise between the individual acoustic correlates and the distinctive feature values.

Two IPPs are proposed in these papers. The first is called the 'low frequency property', because it represents the integration of acoustic properties that concentrate energy at low frequencies in and near a stop specified for [voice], namely, closure voicing and low F1 and F0 at the edges of flanking vowels. The second is called the 'C/V duration ratio', because it represents the integration of closure and preceding vowel duration – closure voicing and F1 values at the edges of flanking vowels also contribute to this IPP. This ratio is substantially smaller in stops specified [voice] than those unspecified for this feature.

Companion experiments using non-speech analogues whose acoustic properties were manipulated in exactly the same way as they were in the original speech stimuli produced the same pattern of results as the original speech stimuli. Because these stimuli were not heard as speech, this identity shows that integration is product of entirely automatic, non-linguistic, auditory processes. Kingston, Diehl, and their colleagues therefore proposed that the collections of acoustic properties that may serve as the correlates of particular distinctive features are precisely those which are integrated by auditory processes. These auditory processes transform the acoustic properties received at the ear and the outputs of these transformations are mapped onto distinctive feature values.

Crucially, the same intermediate perceptual properties can be produced by integrating any of a number of combinations of acoustic correlates. For example, the low frequency property can be produced by integrating low F1 or low F0 at the edges of flanking vowels with closure voicing.[17] Of equal importance, an acoustic correlate can also contribute to more than one IPP, as does low F1 at the edges of flanking vowels to the integration of closure voicing with closure duration in the C/V duration ratio property, as well as the low frequency property. The IPPs are not the distinctive feature values themselves because more than one corresponds to each value – for example, the low frequency property and a small C/V duration ratio correspond to [voice] – and not all of them can be present in all contexts – for example, both the low frequency property and a small C/V duration ratio correspond to [voice] in stops between vowels, but only the low frequency property does in stops at the beginnings of words. The catalogue of phonetic properties in the signal that may correspond to a particular distinctive feature value consists of those that may integrate perceptually into one of the IPPs corresponding to that feature. Similarly, variation between contexts or languages in the phonetic properties that can realize that feature value is limited to those that may integrate into one of its characteristic IPPs. Thus, it is at the level of the IPP and not the individual articulation, acoustic property, or simple auditory quality (simple in the

[17] See Stevens & Blumstein (1981) for the earliest proposal that various acoustic correlates of the [voice] contrast cohere to produce a percept of low frequency energy in and near a [voice] stop closure.

sense of not being the product of integration) that a sufficient degree of invariance is found between distinctive feature values and their phonetic exponents to maintain a small number of universal distinctive features.

If phonological features are defined phonetically by their IPPs, then their values cannot be determined from the speaker's articulations nor by their acoustic consequences but only by the perceptual products of auditory integration (compare the proposals for articulatory invariants in Liberman, Cooper, Shankweiler, & Studdert-Kennedy (1967); Liberman & Mattingly (1985, 1989); Browman & Goldstein (1986, 1989, 1990, 1992); for acoustic invariants in Stevens & Blumstein (1978); Blumstein & Stevens (1979, 1980), and for relational acoustic invariants in Lahiri, Gewirth, & Blumstein (1984); Sussman, McCaffrey, & Matthews (1991); Sussman, Fruchter, Hilbert, & Sirosh (1998)). IPPs permit listeners to identify distinctive feature values from partial and variable phonetic information, so long as a sufficient number of the possible acoustic contributors to an IPP that maps onto that distinctive feature value are present in the signal. IPPs also let us avoid using ill-defined cover features such as tense/lax or fortis/lenis to represent the contrast, cf. Kohler (1984).

Distinctive feature values can be phonetically polymorphous (Kluender, 1994) because all the combinations of phonetic properties that realize them in different contexts or languages produce perceptual effects that are sufficiently similar for these ostensibly different pronunciations to count as instances of the same phonological category.

A brief comment is in order about [spread glottis] and an apparent difference between it and [voice] before proceeding to the next stage in the argument. The arguments developed in this section make it appear that [voice] contrasts are quite variable in their pronunciations across contexts and languages, and for that reason harder to recognize as such than apparently invariant [spread glottis] contrasts. However, [spread glottis] contrasts are also variable in their pronunciation, in whether the intervals outside the stop closure during which the glottis is spread are wholly voiceless or at least partly breathy-voiced (Gandour, 1974; Kingston, 1990; K. Davis, 1994; Mikuteit & Reetz, 2007), and in whether F0 is higher in vowels flanking those specified for [spread glottis] or those that are unspecified for this feature (Kingston & Diehl, 1994). Finally, the properties that characterize the [spread glottis] contrast in Mikuteit & Reetz's 2007 analysis of Bengali and German suggest that they, too, have the characteristics of IPPs. The pronunciation of [spread glottis] is thus no more invariant than that of [voice].

In the next section of this paper, we reconsider the history of laryngeal contrasts in Germanic stops, beginning with a summary of Iverson & Salmons's account, followed by our objections to it. This reconsideration shows that the contrast was and remains [voice] rather than [spread glottis].

4 The history of Germanic stops

The modern Germanic languages all contrast at most two series of stops, which are written using the Latinate orthography with the symbols, <b, d, g> and <p, t, k>, that depict voiced and voiceless stops in Romance languages. Aside from the southernmost Germanic languages, Swiss German and Bavarian, where these symbols now represent a quantity contrast between singletons and geminates (Kraehenmann, 2003; Bannert, 1976; Seiler, 2005), these two sets of symbols represent a two-way laryngeal contrast in all the other present-day Germanic languages. Until recently, this laryngeal contrast has been analyzed as [voice] in all the daughter languages other than North Germanic Icelandic and Faroese, where it is instead [spread glottis]. Similarly, in the traditional philological literature, proto-Germanic stops have been reconstructed with a [voice] contrast (Brugmann, 1886-1893; Paul, 1891). Here, we set out to show that this analysis is correct, and that Iverson & Salmons's reanalysis of the laryngeal contrast as [spread glottis] is not.

4.1 Iverson & Salmons's Account

Iverson & Salmons (1995, 1999, 2003, 2007) present a quite different history for Germanic stops. They propose that [spread glottis] has repeatedly enhanced the laryngeal contrast between these two series of stops since the First Consonant Shift (Grimm's Law) separated Germanic phonologically from Proto-Indo-European (others have made similar proposals; for example, Voyles (1992, pp. 63, 210) describes aspiration of voiceless stops as a 'persistent rule' in Germanic). Indeed, in Iverson & Salmons's reanalysis of Germanic diachrony, [spread glottis] triggered both the First Consonant Shift and the Second Old High German (OHG) Consonant Shift (see also Voyles, 1992).

We begin this appraisal of their proposal by drawing the reader's attention to a point to which Iverson & Salmons have paid too little attention: aspirated stops do not generally correspond in English and German, as can be seen in Table 11, which shows the German and English reflexes of Proto-Germanic singleton and geminate stops. Correspondences are also given in the table for Dutch (representing Low German) and Swiss German (representing High German).[18]

Voiceless aspirated stops in modern English descend directly from Proto-Germanic *p, *t, *k. They correspond to voiceless unaspirated stops in modern Dutch, but to voiceless affricates or fricatives in modern German (and Swiss German). The English and Dutch reflexes are pronounced without affrication because the ancestors of these languages did not undergo the Second Consonant Shift, which affricated Proto-Germanic *p, *t, *k, uniformly in Old Alemannic, the ancestor of Swiss German, and all but the velar stop elsewhere in Old High German, the ancestor of modern German.[19] Velar [k^h] (< *k / #-, N-, *kk) is thus

[18] The double consonants were true geminates until late medieval times, when they degeminated in Dutch, English and German but not in Swiss German (Lahiri & Dresher, 1999).

[19] See Vennemann (1985, 1994) and G. W. Davis, Iverson, & Salmons (1999) for discussion of the incompleteness of the Second Consonant Shift in OHG. All places of articulation shift in all contexts in the southernmost variety, Alemannic, but in more northern varieties, fewer places of articulation, dorsals less

Proto-Germanic			German			English			Dutch			Swiss German		
p	t	k	pf	ts	k^h	p^h	t^h	k^h	p	t	k	pf	ts	kx
-p	-t	-k	-f(f)	-s(s)	-x(x)	-p	-t	-k	-p	-t	-k	-ff	-ss	-xx
-pp-	-tt-	-kk-	-pf-	-ts-	-k^h-	-p(p)	-t(t)-	-k(k)-	-p(p)-	-t(t)-	-k(k)-	-pf-	-ts-	-kx-
-Np	-Nt	-Nk	-Npf	-Nts	-Nkh	-Np	-Nt	-Nk	-Np	-Nt	-Nk	-Npf	-Nts	-Nkx
	þ			d			θ			d			t	
b	d	g	b	t^h	g	b	d	g	b	d	x	p	tt	k
-b-	-d-	-g-	-b-	-t-	-g-	-b-	-d-	-g-	-b-	-d-	-x-	-p-	-tt-	-k-
-bb-	-dd-	-gg-	-b(b)-	-t(t)-	-g(g)-	-b(b)-	-d(d)-	-g(g)	-b(b)-	-d(d)-	-x(x)-	-pp-	-tt-	-kk-

Table 11: Proto-Germanic stops in the various contexts in which they occur and their reflexes in representative present-day West Germanic languages.

the only voiceless aspirated stop that corresponds between German and English, and it does so only because PG *k failed to undergo the Second Consonant Shift in the OHG ancestor of German. Otherwise, modern German [p^h, t^h] and many instances of [k^h] have entirely different sources: all [p^h] come from loans, [t^h] comes either from *d or from loans, and the [k^h]s that do not descend from *k also come from loans. Beside these phonetically diverging correspondents in the OHG versus non-OHG reflexes of the Proto-Germanic *p, *t, *k are the phonetically uniform and conservative reflexes of *b, *d, *g, which descend unchanged, except for *d > t in OHG and *g > x in Dutch. The phonetic reflexes of *b, *d, and *g are illustrated by the cognate sets in the last three rows of Table 12.[20]

Proto-Germanic	German	English	Dutch
*p	pfanne [pf]	pan [p^h]	panne [p]
*t	Zahl [ts]	tale [t^h]	taal [t]
*rt	herz [ts]	heart [t]	hart [t]
*þ	denken [t]	think [θ]	denken [d]
*b	beginnen [p]	begin [p]	beginnen [b]
*d	Tag [t^h]	day [t]	dag [d]
*g	gehen [k]	go [k]	gaan [x] ¡ *g

Table 12: German, English, and Dutch cognates illustrating phonetic reflexes of Proto-Germanic *p, *t, *þ, *b, *d, *g.

The failure of voiceless aspirated stops to correspond between English and German, except when a stop failed to undergo the Second Consonant Shift in OHG shows that this pronunciation cannot have a common historical source in the two languages. Even if the sounds symbolized by <p, t, k> are specified [spread glottis] in both languages, that state of affairs cannot have been inherited from their common ancestor. To be sure, Iverson & Salmons do not claim that they were, but instead describe the situation as one in which a voiceless aspirated pronunciation has become persistent phonetic practice in West Germanic

than labials less than coronals, are affected in fewer contexts, word-initial less than intervocalic or after a sonorant.

[20] The replacement of earlier [g] by [x] in Dutch is a much later change.

languages,

> 'Germanic Enhancement [= acquisition of [spread glottis] by voiceless stops, KLD] was not a one-time modification of voiceless stops, but rather, we think, introduced a new basis of articulation for the language to the effect that voiceless stops came to be produced as aspirated whenever they can be, whenever they arise, from whatever source.' (Iverson & Salmons, 2003, p. 67)

> 'We suggest simply that such settings [= Germanic Enhancement, KLD] can persist not only across generations – that is, they can be acquired by learners in the speech community – but they can also survive significant segmental changes and phonological reorganizations. It is possible, in other words, to maintain a stable 'articulatory set' at a phonetic level in the face of phonological changes in the same component of the sound system. We see the introduction of Germanic Enhancement as a change in the articulatory setting of Germanic speakers, one which triggered a set of reorganizations that continues to this day.' (p. 68)

In other words, voiceless aspirated stops do not correspond between the descendents of Old High German (e.g. modern German) and descendents of other branches of West Germanic (e.g. modern English), but they develop repeatedly in different branches because Germanic acquired a phonetic preference for aspirating voiceless stops, or a 'persistent rule' (see also Voyles, 1992).

According to Iverson & Salmons (1995, 2003), this phonetic preference arose at the earliest stage in the history of Germanic as an essential precursor to the sound change known as the First Consonant Shift or Grimm's Law (Table 13a), which transformed the original Proto-Indo-European system of laryngeal contrasts into that reconstructed for Proto-Germanic.[21]

[21] Between their 1995 and 2003 papers, Iverson & Salmons; Iverson & Salmons adopted Avery & Idsardi's 2001 dimensional representaton of laryngeal contrasts, which replaces [voice] with Glottal Tension and [spread glottis] with Glottal Width. Because the arguments for choosing [voice] or [spread glottis] as the

	Proto-Indo-European		Germanic Enhancement, 1^{st} application		
a.	p t k unspecified	>	[spread glottis]	=	[p^h, t^h, k^h]
b.	(b)[a] d g [voice]				
c.	b^h d^h g^h [voice, spread glottis]				

Table 13: Pre-Proto-Germanic after the enhancement of /p t k/ by [spread glottis] but before the First Consonant Shift. [a]As is well-known, reflexes of PIE *b are rare, which raises doubts as to whether this sound can be reconstructed.

At this stage, *b, *d, *g contrasted privatively for [voice] with *p, *t, *k, but this contrast was redundantly enhanced by the aspiration (= [spread glottis] specification) of the unspecified series, *p, *t, *k. This enhancement set the stage for the First Consonant Shift (Table 14) by making the voiceless stops phonetically similar to voiceless fricatives, which are predictably specified [spread glottis] (Löfqvist & Yoshioka, 1980, 1984; Löfqvist, Baer, & Yoshioka, 1981; Yoshioka, Löfqvist, & Hirose, 1981).

	Pre-Proto-Germanic		Proto-Germanic
a.	p^h t^h k^h [spread glottis]	>	f þ x [continuant]
b.	(b) d g [voice]	>	(p) t k unspecified
c.	b^h d^h g^h [voice, spread glottis]	>	b d g [voice]

Table 14: Pre-Proto-Germanic to Proto-Germanic: The First Consonant Shift.

Once the unspecified series of stops became fricatives (Table 14a), the specification of laryngeal contrasts in the other two stop series would then have simplified, in a classic drag chain (Table 14b, c), in which [voice] is lost from *b, *d, *g because these stops no longer contrast with an unspecified series, and then [spread glottis] is lost from *b^h, *d^h, *g^h because these stops no longer contrast with stops specified for [voice] but not [spread glottis]. The First Consonant Shift thus begins with the acquisition of the marked value for [continuant], facilitated by the redundant specification of *p, *t, *k for [spread glottis], while the second and third steps are the loss of marked specifications from the remaining series of stops, first for

distinctive feature do not change if these features are replaced by the dimensions Glottal Tension or Glottal Width, we will continue to refer to the contrast in terms of the features rather than Avery & Idsardi's dimensions.

[voice] and then [spread glottis].

Reflexes of this first change can be found in all modern Germanic languages; however, only the ancestor, Old High German, of the High German subgroup underwent a subsequent change, the Second Consonant Shift (Table 15), in which Germanic Enhancement added a [spread glottis] specification to the newly unspecified voiceless stops, which then affricated (Iverson & Salmons, 2003; G. W. Davis & Iverson, 1995; G. W. Davis et al., 1999):

Proto-Germanic		Germanic Enhancement, 2^{nd} application		Old High German
*p, *t, *k	>	p^h t^h k^h	>	pf ts kx

Table 15: The Second or Old High German Consonant Shift.

This [spread glottis] specification would at first have been redundant, just as it was prior to First Consonant Shift, but would become contrastive as a result of Proto-Germanic *b, *d, *g losing their specification for [voice]:

Proto-Germanic		Germanic Enhancement		Loss of [voice]
/p t k/	>	[p^h t^h k^h] redundant		/p^h t^h k^h/ contrastive
/b d g/			>	[b̥ d̥ g̊] devoiced

Table 16: Enhancement of Proto-Germanic /p t k/ by [spread glottis] and devoicing of /b d g/.

The Second Consonant Shift is only complete in the southernmost descendents of Old High German, the Swiss German dialects. Farther north, in modern German, the coronal and labial but not the dorsal stops have undergone the change. The affricates remain unchanged initially and after sonorant consonants; but after vowels they became geminate voiceless fricatives, [ff, ss, xx],[22] which ultimately degeminated in late medieval times. In the rest of Germanic, the aspirates subsequently descend unchanged (Table 17).

Germanic Enhancement would have made the shift of the contrast from [voice] to [spread glottis] possible or even probable by providing speakers with another, perhaps more robust

[22] Only the shift to affricates is dialectly restricted; all modern descendents of OHG show fricative reflexes of these geminate fricatives.

OHG	German	English	Dutch	Icelandic
[pf]lan[ts]ōn	[pf]lan[ts]e	plant	plant	[p^h]lan[t^h]a
si[tts]an	si[ts]en	sit	zitten	si[t^h]ja
slā[ff]en	schla[f]en	sleep	slapen	not cognate
scā[ff]	Scha[f]	sheep	schaap	ske[^{h}p]na
skif	Schi[f]	ship	schip	ski[p^h]
sā[s]	sa[s]	sat	zat	sa[t^h]
gei[s]	Gei[s]	goat	geit	gei[t^h]
buo[x]	Bu[x]	book	boek	bo[k^h]
buo[xx]um ‘book, dative’				

Table 17: Old High German and modern German cognates illustrating the Second Consonant Shift, with cognates from English, Dutch, and Icelandic for comparison.

phonetic means of distinguishing the two stop series; see Vaux & Samuels (2005) for extensive discussion of languages’ preference for a [spread glottis] rather than a [voice] contrast, cf. Keating, Linker, & Huffman (1983); Keating (1984) for contrary evidence.

Summing up, Iverson & Salmons propose that on two occasions in the history of Germanic an unspecified series of voiceless stops has acquired a redundant specification for [spread glottis] by Germanic Enhancement (GE), and that specification has led to the sound being pronounced with local friction. In both cases, acquiring this specification is a precursor to a sound change: the First Consonant Shift in the transition from Proto-Indo-European to Proto-Germanic and the Second Consonant Shift in the transition from Proto-Germanic to Old High German (Table 18).

PIE		GE, 1^{st}		PG		GE, 2^{nd}		OHG
Consonant Shifts			First				Second	
p t k	>	p^h t^h k^h	>	f þ x				
b d g			>	p t k	>	p^h t^h k^h	>	pf ts kx
								cf. E p^h t^h k^h

Table 18: Repeated enhancement of /p t k/ by [spread glottis] in the history of Germanic.

In other words, aspiration or a [spread glottis] specification is seen as a necessary first step toward becoming noisy and wholely or partially [continuant] twice in the history of the family. Indeed, G. W. Davis et al. (1999) have also asserted that PG voiceless stops would have to be aspirated if they were to turn into affricates at the beginnings of words in German (see Table 11).

G. W. Davis & Iverson (1995) propose that affrication took place in Old High German in two steps.[23] First, the stop's [spread glottis] ([sg]) specification delinked from the stop, turning mono-segmental [p^{h}] into bisegmental [ph] (Table 19a). The place specification of the stop ([lab]) then spread to the second segment, producing the affricate [pf] (Table 19b):

a. Delinking:	PGmc [p^{h}] = [p] [lab] [sg]	>	pre-OHG [ph] =[p] [lab] [h] [sg]
b. Spreading:	Pre-OHG [ph]	>	[pf] = [p] [lab] [f] [lab] [sg]

Table 19: Affrication in OHG: Labial example.

Presumably then, the 'segmentalization' (G. W. Davis & Iverson, 1995, p. 114), which turned [p^{h}] to [ph], did not happen in English; else, we would have expected affrication in English as well. Again, it is uncertain what could have happened in Dutch.

Before responding to this account, we briefly recount Vennemann's 1985 similar proposal.

4.2 Vennemann's Account

In his 'bifurcation' account of the history of Germanic stops, Vennemann (1985) also assumes that aspiration is a precursor to the First Consonant Shift (Table 20). For Vennemann, however, the PIE series that produced the voiceless fricatives in Proto-Germanic was contrastively, not redundantly specified [spread glottis]. He describes the series represented by <p' t' k'> as voiceless, unaspirated, and fortis, resembling the 'tense' series in Korean. This series replaces the voiced series *b, *d, *g in the traditional PIE reconstruction. The voiced aspirates *b^{h}, *d^{h}, *g^{h} of that reconstruction are also replaced, by a series of unaspirated, devoiced, lenis stops, b̥ d̥ g̊, which differ only notationally from the 'lax' stops in Korean.

[23] G. W. Davis & Iverson represent aspiration with [spread glottis] rather than Glottal Width, and we follow their usage in discussing their proposal.

Vennemann thus reconstructs the PIE stop contrasts much like those who espouse the glottalic theory (Gamkrelidze & Ivanov, 1973; Hopper, 1973).[24] Vennemann's account also differs from Iverson & Salmons's in that he treats the aspiration of /p t k/ as the **outcome** of the Second Consonant Shift in the Germanic languages whose stops were not affricated by the Second Consonant Shift, rather than a **precursor** to that shift.

PIE		Proto-Germanic			
	First		Second		
p^h t^h k^h	>	f þ x	>	f þ x	OHG, Low German
p’ t’ k’	>	p’ t’ k’	>	pf ts kx	OHG
				p^h t^h k^h	non-OHG
b̥ d̥ g̊	>	b̥ d̥ g̊	>	b̥ d̥ g̊	OHG, Low German

Table 20: Changes in stops from Proto-Indo-European to Proto-Germanic to the bifurcation between Old High German and Low German, according to Vennemann (1985).

4.3 Objections

Here, we raise eight objections to these accounts:

1. If English voiceless stops acquired or retained a [spread glottis] specification, why did the Dutch stops not do so, too? A number of scholars have suggested that the replacement of a [spread glottis] contrast by a [voice] contrast in the ancestor of Dutch, along with a number of other peculiarities that set Dutch apart from the rest of Germanic, are products of sustained contact with Romance languages (Haeringen, 1934; Kloeke, 1954; Weijnen, 1958; Coetsem, 1988) or derive from a pre-Germanic Italic substrate (Gijsseling, 1981; Vennemann, 1994). But why then did sustained contact with the laryngeal contrast of another Romance language, Norman French, not have the same effect on the pronunciation and phonology of the English stops, too?

[24] Like that account, Vennemann's also addresses the rarity of reflexes of PIE *b. If that consonant were actually *p’ instead, then it might actually have been absent in PIE much as labial ejectives are absent in other languages with ejectives such as Tigre, Hausa, Navajo, Zuni, and Jacaltec.

2. If aspiration is a persistent articulatory setting that enhances Germanic voiceless stops, why would it also repeatedly be the cause of, or at least the prerequisite for sound changes that replace voiceless stops with sounds of a different manner of articulation, non-strident fricatives produced by the First Consonant Shift and strident affricates and fricatives produced by the Second?

3. According to Iverson & Salmons's account, Germanic Enhancement has triggered two sound changes in the history of Germanic, the spirantization of PIE voiceless stops to non-strident fricatives known as the First Consonant Shift, and the affrication of PG voiceless stops in OHG known as the Second Consonant Shift. Before either of these changes came about, Germanic Enhancement had the same phonological side effect: stops that were formerly specified [voice] lost this specification and devoiced as the initially redundant [spread glottis] specification became contrastive, see (Tables 14 and 18). In languages like English that did not subsequently undergo the Second Consonant Shift, the result of this switch in the contrast from [voice] to [spread glottis] has persisted to the present-day. This side effect raises a very basic question: why should the contrast ever have switched?

We referred above to Vaux & Samuels (2005), who argue that a [spread glottis] contrast is more robust than a [voice] contrast, but there is very little evidence that this is so, and considerable evidence to the contrary. First, in Keating et al.'s 1983 survey of instrumental studies of languages with a two-way laryngeal contrast in their stops, 17 distinguish prevoiced from voiceless unaspirated stops, while only 6 contrast voiceless unaspirated with voiceless aspirated stops; an additional 13 contrast prevoiced with voiceless aspirated stops. Second, voicing should be detected easily during a stop closure, because it is at low frequencies and little if any high frequency energy is present. In this connection, Hay (2005) demonstrates that listeners may distinguish between prevoiced from voiceless unaspirated stops on the basis of the presence versus absence of closure voicing rather than using the temporal asynchrony between voicing onset and the stop release. Her results show that the use of temporal asynchrony may be limited to distinguishing between voiceless unaspirated and voiceless aspirated stops. Third, many Indo-European languages (Romance, Slavic, Greek) have apparently distinguished their stops for [voice] without replacing that contrast by [spread glottis] for very long periods of time, for example, throughout the 2000 or more year long period from Latin to the present-day Romance languages. Fourth, within Germanic itself, the only languages that have undoubtedly replaced [voice] with [spread glottis] are Icelandic and Faroese. Swedish contrasts prevoiced and voiceless aspirated stops initially for some speakers (Löfqvist, 1976; Petrova, Plapp, Ringen, & Szentgyörgyi, 2006; Helgason & Ringen, 2008), which shows that even when speakers of a language come to pronounce their /p, t, k/ with aspiration, they need not give up voicing in pronouncing their /b, d, g/.[25] That is, the voiceless unaspirated pronunciations of /b, d, g/ at the beginnings of words by English and German speakers are not a necessary concomitant of their aspirated pronunciations of their /p, t, k/. It is very likely the other way around: /p, t, k/ are aspirated initially in English and German because /b, d, g/ are usually pronounced without voicing in this context (Docherty, 1992), presumably because voicing is aerodynamically more difficult to initiate (Kingston & Diehl, 1994). These considerations all suggest that a [voice] contrast is no less robust than a [spread glottis] contrast.[26]

4. The changes affecting PG *þ also present a difficulty for Iverson & Salmons. This sound becomes a voiced stop /d/ in Dutch and German (and remained unchanged in English). Why did it not become a voiceless aspirated stop instead? After all, by virtue of being a voiceless fricative, it was already [spread glottis] and a change from [continuant] to

[25] As mentioned in footnote 2, some speakers of Swedish consistenly pronounce initial /b, d, g/ without any prevoicing.

[26] For the sake of discussion in this paragraph, we have assumed that voicing during the closure is the typical correlate of a [voice] contrast in stops, while aspiration is the typical correlate of a [spread glottis] contrast.

non-continuant would have reduced markedness. Development into [t^h] would not have been inhibited by the prospect of neutralizing any contrast in the ancestor of German because the Second Consonant Shift had eliminated /t/ before *þ changed to /d/. In any case, Dutch already had a /t/ as well as a /d/, so the prospect of neutralization had no power to inhibit the change this sound underwent in that language.

5. The outcomes of the Second Consonant Shift are decidedly different from that of the First. The First Consonant Shift produces non-strident homorganic fricatives from the original voiceless stops, while the Second produce strident affricates, which later become geminate strident fricatives after vowels.

This difference prompts the obvious question: why then did the Second Consonant Shift produce such a different outcome from the first? One possibility is that the inputs to the two changes differed, voiceless unaspirated stops in PIE as the input to the First Consonant Shift versus voiceless aspirated stops in PG as the input to the Second.[27] Alternatively, the inputs could have been the same, voiceless stops in both instances, but the systems of contrasts that existed prior to the change could have differed. We take up the second alternative here.

Prior to the First Consonant Shift, we find the contrasts between obstruents in PIE given in Table 21 (the symbols for coronal stop are used to represent all places of articulation for stops; the only fricative was [s]):

In a system like this with just a single strident fricative, it is easy to see how voiceless stops could lenite to non-strident homorganic fricatives, *t > þ, etc. without neutralizing any contrasts nor adding any to the inventory. [s] was presumably already [strident], even if that specification was redundant in PIE. The introduction of /þ/ by

[27] This alternative is not available to Iverson & Salmons, as they propose that the PIE voiceless unaspirated stops acquired a redundant [spread glottis] specification prior to and as a prerequisite to the First Consonant Shift. This proposal makes the dispararate outcomes of the First and Second Consonant Shifts even more mysterious.

a.	d^h	[voice, spread glottis]
b.	d	[voice]
c.	t	
d.	s	[continuant]

Table 21: PIE (coronal) obstruents before the First Consonant Shift.

the First Consonant Shift made that specification contrastive. The ensuing changes, PIE *d > PG t and PIE *d^h > PG d also neither neutralize nor add contrasts.

Once a whole series of voiceless fricatives are present, however, any subsequent change from stops to fricatives would have to produce quite different outputs, as happened in the Second Consonant Shift (Table 22).

a.	p	>	pf, ff
b.	t	>	ts, ss
c.	k	>	kx, xx

Table 22: The Second Consonant Shift. The affricate reflex occurred at the beginning of words and after sonorants, the geminate fricative reflex after a vowel.

Prior to the Second Consonant Shift, the system of obstruents at each place of articulation consisted of a stop specified [voice], an unspecified stop, a non-strident fricative, and at the coronal place a strident fricative (Table 23).

a.	d [voice]
b.	t
c.	þ[continuant]
d.	s [continuant, strident]

Table 23: Proto-Germanic obstruent contrasts before the Second Consonant Shift.

If /t/, etc. were also to become [continuant], they would have to acquire some property that would distinguish them from the existing continuants. [strident] is not enough, as there was already an [s], so at first they became only partial continuants, during their [strident] interval, and later geminate strident continuants in contexts where they became full continuants (Table 24).

	PG	Second	Affricate	or	Fricative
b.	t	>	t-s / { # _ , [+son] _ } 0-cont 0-strid	or	s-s / V_ cont-cont strid-strid
c.	þ [cont]				
d.	s [cont, strid]				

Table 24: Development of Proto-Germanic /t/ into [ts] and ultimately [ss] after vowels in Old High German, in the context of existing þ and s.

As there were already geminate stops, there was already a contrast for length in the system that they could exploit.

6. G. W. Davis & Iverson's segmentalization proposal, [p^h] > [p.h], etc. is highly implausible. There appear to be no other cases in which an aspirated stop fissions into an unaspirated stop and a glottal fricative in this way. Indeed, quite the contrary, clusters such as [ph] instead become aspirated stops, or are typically phonetically indistinguishable from them, as for example in Korean (an example cited by G. W. Davis & Iverson themselves). If this were not bad enough, fission of [p^h] into [p.h] creates a very serious violation of syllable contact, as the resulting onset [h] is decidedly more sonorous than the resulting coda [p]. G. W. Davis & Iverson appeal to syllable contact later as motivation for eventually turning [p.f] into [f.f], so they apparently think that this constraint is operative in this language at this time in its history. How then can it be so egregiously violated during the putative first step in the sound change?

We are inclined to a more neutral account in which aspiration, if it were there at all, is simply strengthened into affrication (if we do not instead assume that affrication is secondary, as suggested above). G. W. Davis & Iverson object to this alternative on the grounds that they cannot see how a laryngeal articulation could be transformed into an oral one, but this is exactly where an auditory perspective is advantageous. Affrication is simply more local (and more intense) post-release noise than aspiration. That is, something very close to [pf] would be produced if the aspiration noise in [p^h]

were particularly intense. Any enhancement would more likely be in the adjustment of the oral articulation to make the fricative interval strident. Stridency is a product of directing the jet emerging from the fricative constriction at an obstacle just downstream, against which it breaks up and dramatically increases the noisy turbulence in the air flow (**?**). For a labial articulation, this configuration is achieved by drawing the lower lip behind the upper incisors, directing the jet upward to break up against the upper lip, and thereby replacing non-strident [ɸ] with strident [f]). For a coronal articulation, it is achieved by introducing a groove [s] or slit [ʃ] onto the surface of the tongue through which the jet is directed at the upper teeth. The velar may have failed to affricate in most descendents of OHG because there is no obstacle near enough downstream against which the jet flowing out of the dorsal constriction could break up.

7. The second and third sound changes in what is now the standard account of the First Consonant Shift, devoicing of the voiced stops following the spirantization of the voiceless stops and deaspiration of the voiced aspirates following devoicing appear to be the only possible consequences of the prior changes. But this appearance is deceptive, and alternative changes were equally likely. That these alternative changes did not occur raises doubts as to whether voiceless stops ever underwent Germanic Enhancement. Why did voiceless aspirates not devoice along with the PIE voiced stops rather than deaspirating? The resulting system would have consisted of non-strident voiceless fricatives (< PIE voiceless stops), voiceless unaspirated stops (< PIE voiced stops), and voiceless aspirated stops (< PIE voiced aspirates), that is, the stop inventory of modern Icelandic. Only the immediate enhancement of the newly devoiced stops by the addition of [spread glottis] could have have forestalled this outcome. However, the absence of aspirated reflexes of PG /p,t,k/ in Low German, Old Saxon, and Dutch[28] indicates that this series could not have been enhanced immediately after

[28] The development of aspirated pronunciations in the North Germanic languages is probably also a much

devoicing. Specification for [spread glottis] would itself motivate devoicing if aspiration and voicelessness enhance each other. For Iverson & Salmons's account to go through, enhancement would have to be one-way – [spread glottis] enhances voicelessness – and not mutual. But if this combination of properties has the virtue of perceptual salience, why would PG speakers have avoided devoicing of the PIE voiced aspirates to produce it? Finally, devoicing rendered the PIE voiced stops unspecified for any laryngeal feature. Why then would any specification for a laryngeal feature be added to them, marking them once again?

8. Finally, if voiceless stops are enhanced by the addition of [spread glottis], why are they not so enhanced in all contexts in which they occur? That is, why does the duration of aspiration vary systematically between contexts in English and German rather than being long everywhere if these languages have adopted an articulatory setting in which "voiceless stops came to be produced as aspirated whenever they can be" (Iverson & Salmons, 2003, p. 67). We proposed above that aspiration or the spreading of the glottis that produces it varies between contexts so as to convey information about the prosodic constituency of the utterance. This purpose differs from enhancement in predicting the observed systematic variability between contexts.

In the next section, we describe a number of phonetic and phonological patterns which unite Dutch, the one West Germanic language which everyone agrees contrasts its stops for [voice] with English and/or German, the languages that Iverson & Salmons claim contrast their stops for [spread glottis] instead. These facts indicate that the contrast is actually the same in all three languages, and moreover that it is [voice].

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later development.

5 Phonetic and phonological patterns uniting the West Germanic languages

5.1 Introduction

The nature of the evidence is the same in all the cases presented in this section: in terms of their laryngeal articulations, Dutch obstruents pattern phonetically and phonologically in the same way as the corresponding English and/or German obstruents do. The identity of these patterns in Dutch and one, the other, or both of English and German indicates that these laryngeal articulations are the pronunciations of the same laryngeal feature in all three languages, namely, [voice]. We have furthermore found just a single pattern that is common to English and German but absent from Dutch; otherwise, when English and German pattern alike, Dutch does, too. The near total absence of cases that at once unite English and German and separate them from Dutch indicates that their obstruents are not specified for a different laryngeal feature, [spread glottis], from Dutch's obstruents. Finally, in some cases we have found that these three West Germanic languages pattern alike, but differently from Icelandic, a North Germanic language whose obstruents are universally acknowledged to contrast for [spread glottis] rather than [voice]. In short, English and German obstruents do not participate in patterns that distinguish them from Dutch obstruents nor that ally them with Icelandic obstruents, quite the reverse in both instances. This outcome leads us to conclude that the obstruents in just one of the these languages, Icelandic, contrast for [spread glottis], while those in the other three languages instead contrast for [voice]. Below, we list the phonetic and phonological patterns that unite the West Germanic languages (together with the sections where each is discussed):

1. Dutch, English, German versus Icelandic:

    (a) PG voiced stops correspond in English, Dutch, and German, but they have spirantized in Icelandic (5.2).

(b) Vowels are longer before voiced than voiceless obstruents in the West Germanic languages but not before unaspirated than aspirated obstruents in Icelandic (5.3).

(c) Obstruents in word-internal clusters agree in voicing in Dutch, English, and German (5.6).

(d) /b, g/ have been lost after nasals word-finally in Dutch, English, and German, but not Icelandic (5.7.1).

2. Dutch and English versus German:

   (a) The past tense suffix alternates for voicing as function of the voicing of the stem-final consonant in both Dutch and English, though not German (5.5).

   (b) In Dutch and English, many words end in /lp/ but few or none in /lb/, while in German, many words end in /lb/ and few or none in /lp/ (5.7.3).

3. Dutch and German versus English:

   (a) Phonologically long vowels precede [z] and short vowels precede /s/ in Dutch and German (5.4); this complementary distribution is absent from English.

   (b) Dutch, English, and German contrast /z/ with /s/ (Dutch and English) or /ts/ (German) after /n/ inside morphemes, but only Dutch and German do so morpheme-finally (5.7.2).

4. English and German versus Dutch: In English and German, many words end in /lk/ but virtually none in /lg/, while Dutch permits /lg/ (pronounced [lx]) as well as /lk/ (5.7.3).

5.2 Stability of voiced stops

The first and perhaps most telling pattern is the diachronic stability of the stops represented by the symbols <b, d, g> in all three languages, which extends even to instances of /b/ and

/g/ in loans. The cognate sets in Table 25 illustrate this stability (the correspondences of interest are italicized):

	English	Dutch	German
a. initial	*b*rother	*b*ruder	*B*rüder
	*b*ed(d)	*b*ed(d)	*b*et(t)
	*d*aughter	*d*ochter	*t*ochter
	*d*ead	*d*ood	*t*ot
	*g*od	*g*od	*G*ot(t)
	*g*old	*g*oud	*G*old
b. medial	we*b*	we*b*	Gewe*b*e, we*b*en
	ro*bb*er	ro*bb*er	räu*b*er
	OE ha*bb*an)	he*bb*en	ha*b*en
	mi*dd*le	mi*dd*le	Mi*tt*el
	ri*d*e	rij*d*en	rei*t*en
	be*g*in	be*g*innen	be*g*innen
	OE li*cg*an [ggj]	li*gg*en [x]	lie*g*en
c. loans	*b*ard	*b*ard	*B*arde < Old Celtic
	*b*aron	*b*aron	*B*aron < French
	*g*allop	*g*allop [x]	*G*alopp < Old French
	ti*g*er	ti*g*er [x]	Ti*g*er < Latin

Table 25: Cognates and loans representing the reflexes of PG [voice] stops in English, Dutch, and German.

At the beginnings of words (Table 25a), medially (Table 25b), and in loans (Table 25c), all three languages have identical forms for /b-, g-, -b-, -g-, -bb-, -gg-/, and English and Dutch have identical forms for /d-, -d-, -dd-/ as well. The German reflexes of the voiced coronal stops are voiceless, e.g. *Tochter*, *Gott*, and *Mittel*.[29] This stability contrasts sharply with the mutability of the voiceless correspondents of these sounds, /p, t, k/, which we have reviewed elsewhere in this paper. This stability is expected if [voice] is synchronically and diachronically the marked member of the opposition between /b, d, g/ and /p, t, k/, because phonological specification for a feature inhibits changes that an unspecified sound may more freely undergo.

[29] The one case where German /d/ appears to correspond to Dutch /d/ (but English /ð/), *Brüder*, *bruder* (brother) is a reflex of */þ/ not */d/.

This argument resembles the one Iverson & Salmons (1995) put forward for [spread glottis] rather than [voice]. They assert that voiceless stops acquired a [spread glottis] specification via the First Consonant Shift at the outset of the history of Germanic, which has persisted in German and English down to the present day. However, the voiced stops are even more stable: they did not mutate into fricatives as a result of that shift and in West Germanic have not undergone much in the way of other sound changes since, either at the beginnings of words or intervocalically – singleton voiced stops have spirantized between vowels in English. A characteristic feature of the North Germanic languages (Danish, Norwegian, Swedish, Icelandic, and Faroese) is spirantization of PG [voice] stops, which took place in their earliest common ancestor, Old Norse.

5.3 Vowel lengthening before voiced obstruents

In present-day English, Dutch, and German, vowels are predictably lengthened before voiced obstruents (House & Fairbanks, 1953; Maack, 1953; Peterson & Lehiste, 1960; Slis & Cohen, 1969a,b; Chen, 1970). For Dutch and English, it is easy to demonstrate this duration difference for both phonologically short and long (or lax and tense) vowels before intervocalic stops. However, two independent sound changes complicate the demonstration in modern German. First, the Second Consonant Shift turned original intervocalic voiceless stops into geminate fricatives, cf. *water* : *Wasser*, leaving only voiced stops in this context, except for [t] (and [tt]) from original *d (and *dd). Second, open syllable lengthening lengthened all vowels phonologically before single medial consonants, including [t] as well as all the voiced stops and nasals; as a result, it is almost impossible to find German words with short vowels followed by an underlying voiced consonant other than a handful borrowed from Low German. Despite these two obscuring sound changes, long vowels are lengthened by following voiced stops in German just as they are in Dutch and English.[30]

[30] The difference in vowel length can only be observed before intervocalic stops in Dutch and German because the laryngeal contrast neutralizes syllable-finally in both languages.

	English		Dutch		German	
	V	Vː	V	Vː	V	Vː
a.	bet	bed				
b.	rate	raid				
c.	petal	pedal	ketting ‘chain’	bedden ‘beds’	hatte ‘had’	Kladde ‘scribbling pad’
d.	fatal	ladle	zetel ‘chair’	zeden ‘morals’	Bete ‘beet’	Feder ‘feather’
e.					Zettel ‘notepaper’	

Table 26: [V]+voiceless stop : [Vː] + voiced stop.

In all three languages, both short vowels (Table 26a,c,e) and long ones (Table 26b,d) are lengthened before /d/ as compared to before /t/. One could argue that vowels differ in duration in the same way in all three languages because /-b-, -d-, -g-/ are pronounced similarly in the three languages, with voicing continuing from the preceding vowel well into if not all the way through the stop closure. However, there is no reason why the phonetic property voicing should be cause the preceding vowel to lengthen phonetically; that is, the physiology of vocal fold vibration in no way commits the speaker to lengthening the preceding vowel (see Kluender et al., 1988, , for extensive argumentation in support of this contention). Even if the preceding vowel were automatically lengthened by the physiology of vocal fold vibration in intervocalic stops, vowels also lengthen before final stops in English, which are not reliably produced with voicing during the closure, for example, in *raid* and *bed* compared to *rate* and *bet*. The close parallel between these facts in Dutch, on the one hand, and in English and German, on the other, is inexplicable if [voice] is the specified feature in Dutch, while it is [spread glottis] in English and German.

In contrast, vowels do not differ in duration before stops in Icelandic, which do contrast for [spread glottis]. Intervocalically, only geminate stops contrast for this feature,[31] as in

[31] If the preaspiration interval were included in the measurement of the preceding vowel duration, vowels would actually be substantially longer before the Icelandic reflexes of */-pp-, -tt-, -kk-/ than */-bb-, -dd-,

[spread glottis] *vakka* [^{h}k:] 'to walk to and fro' versus unspecified *vagga* [k:] 'to cradle' or [spread glottis] *kakka* [^{h}k:] 'to heap up' versus *kagga* [k:] 'keg-oblique'. The durations of the voiced portions of the vowels are virtually identical before both types of consonants; if anything, the voiced portions of vowels are slightly longer before the preaspirated stops, which correspond to the voiceless stops of the West Germanic languages (Garnes, 1976, pp. 43, 46). Thus, speakers of a Germanic language which indubitably contrasts its stops for [spread glottis] do not produce vowels with different durations before contrasting stops, while speakers of two other Germanic languages that have been claimed to contrast their stops for this feature, English and German, do. As English and German pattern in this respect just like Dutch, a Germanic language which indubitably contrasts its stops for [voice], the conclusion is inescapable: English and German also contrast their stops for [voice], not [spread glottis].

5.4 Complementary distribution of phonological vowel length before /s/ versus /z/

In the preceding section, we discussed the effect of the laryngeal contrast in obstruents on the phonetic duration of preceding vowels, an effect that can be observed in phonologically short as well as long vowels. Here we turn to restrictions on the distribution of phonologically short and long vowels in Dutch and German imposed by the [voice] contrast in fricatives (English does not exhibit these restrictions). In both Dutch and German, voiced and voiceless fricatives contrast intervocalically,[32] and in both languages vowels are predictably long before the voiced fricatives but short before the voiceless ones (Table 27). There are very few exceptions to this generalization, for example, Dutch *pasen* 'passover' and German *Strasse* 'street', where phonologically long vowels are followed by the voiceless fricative /s/. Again,

-gg-/.

[32] Although Dutch does contrast /s/ and /z/ word initially, only a few words begin with the voiceless variant (*cent*, *sap*).

if German consonants contrast for [spread glottis] while the Dutch ones contrast for [voice], a cross-linguistic generalization is missed.

Dutch		German	
V:-voiced [z]	V-voiceless [s]	V:-voiced [z]	V-voiceless [s]
hazen 'hare-pl'	gassen 'gas-pl'	Hase 'hare'	hassen 'to hate'
kazen 'cheese-pl'	kassen 'hot houses'	Phase 'phase'	passen 'happens'

Table 27: Compelementary distribution of long and short vowels before [z] and [s] in Dutch and German.

Diachronically, of course, this distribution has nothing to do with the laryngeal contrast, whatever it is, and instead reflects an earlier contrast between singleton /-s-/ and geminate /-ss-/, where vowels lengthened in open syllables before singleton /-s-/ and remained short in closed syllables before geminate /-ss-/. However, the quantity contrast was lost by late medieval times, and original singleton [s] was leveled to [z] on analogy with the long vowel-voiced fricative pattern in the past participles (Lahiri & Dresher, 1999, pp. 700-705). No geminate voiced fricative */zz/ contrasted with geminate voiceless /ss/, so there was no analogical model to prompt leveling of original /ss/ to [z] as well. As a result, the synchronic distribution of vowel length depends on the fricative's specification for [voice].

5.5 Past tense alternations

In this section, we turn to a generalization that encompasses Dutch and English: the identical alternations in the form of the regular (or weak) past tense suffix, which is pronounced as voiceless [t] after voiceless obstruents, but as voiced [d] after voiced obstruents and sonorants, including vowels, in both languages (Table 28). Yet once more, it is difficult to understand how the same alternation, inherited from the same historical source, could be induced by different laryngeal specifications. Furthermore, the assimilation itself would require different synchronic mechanisms - insertion of [spread glottis] for English, but spreading or deletion of [voice] for Dutch.

Dutch				English			
knijpte	[pt]	krabde	[bd]	trapped	[pt]	rubbed	[bd]
lachte	[xt]	lagde	[gd]	cooked	[kt]	begged	[gd]
kuste	[st]	lezde	[zd]	kissed	[st]	raised	[zd]
blafte	[ft]	zeefde	[vd]	laughed	[ft]	lived	[vd]
		woonde	[nd]			banned	[nd]

Table 28: Voicing alternation in the weak past tense in Dutch and English.

German shows a different pattern, namely, no alternation at all: the past tense is always [t] regardless of the voicing or manner of the stem-final consonant; *wohnte* [nt], *lachte* [xt] etc. One might treat [t] as the product of assimilation after stems ending in obstruents as they would all be devoiced syllable-finally, but assimilation would not produce [t] after sonorants. One could argue that the German past tense is specified for [spread glottis], but it could just as well be unspecified for [voice] in contrast to the positive specification of the Dutch and English suffixes.

5.6 Voicing agreement in word-internal clusters

None of the West Germanic languages permit voicing to disagree in obstruent clusters inside morphemes or phonological words; for example, beside *abdomen* both **apdomen* and **abtomen* are impossible in all three. Wagner (2000) proposes that the laryngeal specification of the onset in such clusters is shared by both obstruents. In Dutch, the first stop actually undergoes regressive voicing assimilation. In German, the first obstruent is consistently voiceless, but in that language both [voice] and unspecified stops are pronounced without any voicing during the closure when they appear in an onset that does not follow a sonorant. The absence of voicing in a preceding stop is therefore expected if that stop has assimilated to the pronunciation of the following stop (see Mikuteit, 2006, for extensive analysis of the phonetics of such clusters in German).

5.7 Restrictions on obstruents following sonorants

In this section, we describe a number of restrictions on the occurrence of voiced or voiceless obstruents following sonorants.

5.7.1 Loss of word-final /b, g/ after nasals

In English, Dutch, and German, /b, g/ are deleted after nasals word-finally, but reflexes of these stops are preserved in Icelandic, along with reflexes of PG *p and *k – note that PG *p has become [pf] by the Second Consonant Shift in German.[33]

	English		Dutch		German		Icelandic	
mb	lamb	[m]	lam	[m]	Lamm	[m]	lamb	[mp]
	comb	[m]	kam	[m]	Kamm	[m]	kamb	[mp]
mp	camp	[mp]	kamp	[mp]	Kampf	[mpf]	not cognate	
	damp	[mp]	damp	[mp]	Dampf	[mpf]	damp	[m̥p]
ŋg	ring	[ŋ]	ring	[ŋ]	Ring	[ŋ]	not cognate	
	sing	[ŋ]	sing	[ŋ]	sing	[ŋ]	syng	[ŋk]
	long	[ŋ]	lang	[ŋ]	lang	[ŋ]	lang	[ŋk]
ŋk	drink	[ŋk]	drink	[ŋk]	trink	[ŋk]	(drekk)	
	honk	[ŋk]					hönk	[ŋ̊k]

Table 29: Reflexes of labial and dorsal nasal-[voice] and nasal-[0] stop clusters in English, Dutch, German, and for comparison, Icelandic.

In both German and English, a voiced velar stop is deleted after a velar nasal, but a voiceless one is retained, for example, in the pair *ring* [ŋ] ˜ *rink* [ŋk] in both languages. One could argue that there are no /g/s after the nasal in words spelled <ng> to begin with, but both languages prohibit long vowels before both /ŋg/ and /ŋk/ while permitting them before single nasals, for example in *bin* versus *bean* [ɪ-iː], but *sing*, *sink* do not contrast with **siːng*,

[33] The Icelandic examples here are from the northern dialects, which preserve the contrast between [spread glottis] and unspecified singleton stops after sonorants by devoicing the sonorant before the former (Thráinsson, 1978). Neither northern nor southern dialects preserve the contrast in singletons morpheme-internally after a vowel. When another vowel follows, singleton stops are uniformly post-aspirated in the northern dialects but unaspirated in the southern ones.

**si:nk*. This restriction is expected if there is a /g/ after the /ŋ/ in the underlying form of *sing*, such that it ends in a cluster like *sink* does. Unlike the /k/ in *sink*, the underlying /g/ in *sing* does not surface. Long vowels are prohibited in the same contexts in Dutch, even though *g has become /x/ in that language, for example, *bonk* [ŋk] and *tong* [ŋ] with short vowels are possible, but not **boonk* [Vːŋk] nor **toong* [Vːŋ]. As long vowels are prohibited in the same contexts in all three languages, it is reasonable to suppose that the same consonant, namely, voiced /g/, deletes word-finally after [ŋ] in all of them.[34] If this consonant is [voice] in Dutch, but unspecified for [spread glottis] in English and German, it is again difficult to see any rationale for all three languages treating it alike in this context.

All four languages retain /d/ as well as /t/ after [n] at the ends of morphemes and words:

	English		Dutch		German		Icelandic	
nd	bind	[nd]	bind-	[nd]	bind-	[nd]	bind	[nt]
	find	[nd]	find-	[nd]	find-	[nd]	finna	[n:] inf.
							fundum	[nt] pret. pl.
							fundinn	[nt] past part.
	hand	[nd]	hand	[nt]	Hand	[nt]	hönd	[nt]
	pound	[nd]	pund	[nt]	Pfund	[nt]	pund	[nt]
nt	rent	[nt]	rente ‘pension’	[nt]	Rente ‘pension’	[nt]	renta ‘interest’	[n̥t]
	mint	[nt]	munt	[nt]	Münze	[nts]	mynt	[n̥t]
	punt	[nt]	pont	[nt]	pünte/o (Low German)	[nt]	no cognate	

Table 30: Reflexes of coronal nasal-[voice] and nasal-[0] stop clusters in English, Dutch, German, and for comparison Icelandic.

[34] Long vowels are more generally restricted in Dutch and German, where no long vowel can occur before any word-final nasal-stop cluster in monomorphemic words, while in English, vowels were lengthened before word-final sonorant-voiced stop clusters, for example, in *wild* and *tomb*, other than /ŋg/.

5.7.2 Maintenance and loss of the /s:z/ contrast after /n/

In English, Dutch, and German, /s/ (English, Dutch) or /ts/[35] (German) contrasts with /z/ after [n] inside morphemes (Table 31a versus b); however, only in Dutch and German do these sounds contrast morpheme-finally (Table 31c versus d) – the bare forms cited in (Table 31b) of course all end in [s] or [ts] in Dutch and German as a result of final devoicing, but forms with a vowel-initial suffix show whether the fricative is /s/ or /z/. The only exceptions to this generalization in English are *bronze* and *sans*, both loans from French.[36]

5.7.3 Loss of bilabial or velar stops after /l/

In the case just discussed, Dutch and German pattern alike and English is different. In the next example, we find English and Dutch patterning alike and German different. In English and Dutch, on the one hand, /b/ does not occur word-finally after [l]. There are two exceptions to this generalization in English, *bulb* and *alb*, and apparently none in Dutch. German has a number of very common words in which /b/ follows [l] at the end of the word: *Kalb* 'calf', *Halb* 'half', and *Gelb* 'yellow' – although devoiced word-finally, all these /b/s are voiced when a vowel-initial suffix follows, *Kalbes* 'calf (gen)', *Halbe* 'half (n)', *Gelbe* 'yellow (n)'. German patterns differently because *v became /b/ after /l/, but this sound change did not occur in either English or Dutch, cf. English *calve* and *halve* and Dutch *kalven* and *halveren.* The voiceless bilabial stop, on the other hand, occurs after [l] at the end of many words in both English and Dutch, for example, in English, we find *help*, *gulp*, *alp*, *kelp*, *whelp*, *pulp*, and in Dutch *hulp* 'help', *gulp* 'gulp, swallow', *alp* 'alp', *kelp* 'kelp', *fulp* 'type of cloth', *pulp* 'pulp', *wulp* 'whelp'. In German, only two marginal words end in /lp/, *Skalp* 'scalp' but only in the sense of one taken as a trophy, and *Alp* 'foothill'. When the following stop

[35] Because a voiceless stop [t] regularly intrudes between the [n] and [s] in German, no contrast is possible in this context between [ns] and [nts] clusters; compare English where *prince* can in principle contrast with *prints* despite the frequent intrusion of [t] between the [n] and [s] in *prince.*

[36] *Lens* is only an apparent counterexample as it is a dual form and thus not monomorphemic.

English	Dutch	German
a. [nz]		
frenzy	census	Banse
pansy	mensa	Mensa
enzyme	donzig	Insect
Wednesday	linze	Linze
stanza	bronzen	Insel
influenza		Trenze
b. [ns]		[nts]
fancy	dansen	Funsel
answer	kansel	Munze
insect	insect	Kanzil
pencil	insigne	Kanzler
ransom		Pflanze
census		Grenze
c. [nz]	[ns]	[ns]
bronze	bons	Zins
sans	dons	Hans
	frons	immens
	gans	Gans
		uns
		Eins
d. [ns]		[nts]
dance	dans	Finanz
fence	kans	Kranz
glance	krans	Prinz
prince	lans	Tanz
rinse	mens	Glanz
wince		

Table 31: Nasal-strident fricative or affricate clusters in English, Dutch, and German.

is velar, it is English and German that pattern alike in having many common words with voiceless /k/ after /l/ but virtually none with voiced /g/, for example, in English, we find *elk*, *milk*, *silk*, *bulk*, *sulk*, and in German, *Volk* 'folk', *Kalk* 'lime; calcium' , *Schalk* 'joker', *welk* 'wilted, faded; dead'. English has no words ending in /lg/, while German has just three, all marginal: *Talg* 'talc', *Balg* 'bellows; brat', both of which are quite infrequent, and *Erfolg* 'success', which is derived from *erfolgen*. Unlike English and German, Dutch has many words ending in /lg/ (pronounced [lx]) as well as /lk/, for example, *balg* 'bulge', *belg* 'a Belgian', *galg* 'gallows', *talg* 'tallow', beside *balk* 'plank', *melk* 'milk', *volk* 'folk', *elk* 'elk', *talk* 'tallow; talc', *wulk* 'whelk'.

5.8 Summary

In this section, we have shown that English and/or German obstruents participate in the same phonetic and phonological patterns involving laryngeal contrasts as the Dutch ones do, and that for some patterns these languages differ in the same way from Icelandic. These similarities and differences indicate that the laryngeal contrast in English and German is far more likely to be the same as that in Dutch and different from that in Icelandic. As there is universal agreement that Dutch obstruents contrast for [voice] while Icelandic ones contrast for [spread glottis], they indicate that the English and German obstruents contrast for [voice], too.

6 Conclusion

In this paper, we have presented three arguments for analyzing the laryngeal contrast in the Germanic languages as [voice] not [spread glottis] (aside from Icelandic and Faroese, where it is [spread glottis], and Swiss German and Bavarian, where it is no longer a laryngeal contrast but instead one of quantity). The first argument is that distinctive features do not have essential phonetic definitions (3. We demonstrated that it is nonetheless still possible to define distinctive features phonetically, because variable acoustic properties integrate perceptually (3.4). Distinctive features are otherwise more perspicuously defined by the phonological patterns in which they participate, either in the history of the language or its synchronic grammar. The second argument is that the changes that have taken place in course of the historical development of the present-day Germanic languages are better described as referring to [voice] than [spread glottis] (4.3, cf. 4.1 and 4.2). Equally telling is the fact that English and German cannot have followed the same diachronic path to the present-day phonetic resemblance of their /p, t, k/ because English's ancestor did not undergo the Old High German or Second Consonant Shift while German's ancestor did. This sound change affricated or spirantized nearly all voiceless stops in Old High German, and as a result /p, t, k/ in present-day German do not correspond to English /p, t, k/. The third argument is that a large number of synchronic and diachronic phonetic and phonological patterns unite Dutch, the one West Germanic language that everyone agrees contrasts its obstruents for [voice], with English and/or German, where the identity of the laryngeal contrast is in dispute (5). Some of these patterns also separate English and German from Icelandic, a language which does contrast its stops for [spread glottis]. These resemblances and differences indicate that the laryngeal contrast in the same in German and English as it is in Dutch, that is, [voice].

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