Grimm's Law and Verner's Law: Towards a unified phonetic account

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1. Introduction

The systematic changes to stop consonants in Germanic (Gmc) were among the first to be formulated as sound-laws, i.e. 'Grimm's Law' and 'Verner's Law', and their nature has long since been identified (Rask 1818; Grimm 1822-37; Verner 1875).[1]

Essentially, Grimm's Law states that (a) Indo-European (IE) voiceless stops became Gmc voiceless fricatives, (b) IE voiced stops became Gmc voiceless stops, and (c) IE voiced aspirated stops became Gmc voiced (unaspirated) stops; Grimm's Law did not apply when the consonants were preceded by *s*. It is usually assumed that the IE voiceless stops were aspirated. Thus, Grimm's Law clearly affected the stops' manner and force of articulation, whereas their place of articulation remained unchanged. Grimm's Law is laid out in (1), and in a simplified manner in (2) below.

(1) Grimm's Law:
IE voiceless stops /p^h t^h k^h k^{hw}/ > Gmc voiceless fricatives /f θ x x^w/
IE voiced stops /b d g g^w/ > Gmc voiceless stops /p t k k^w/
IE voiced aspirated stops /b^h d^h g^h g^{hw}/ > Gmc voiced stops /b d g g^w/

(2) voiced aspirates > voiced stops > voiceless stops > voiceless fricatives
/b^h d^h g^h g^{wh}/ /b d g g^w/ /p^h t^h k^h k^{hw}/ /f θ x x^w/

Verner's Law states that something more happened to the Gmc reflexes of the IE voiceless stops when the consonant was non-initial and the preceding vowel was not stressed. When the two conditions were met, the IE voiceless stops appear as voiced stops in the Gmc historical record; additionally, IE intervocalic /s/ became /r/ via /z/ in the same environment (rhotacism). Thus, using the coronals as examples, the process is IE t^h > Gmc *θ* (Grimm's Law) > *ð* > *d* (Verner's Law). Verner's Law changes are thus not exceptions to Grimm's Law, but additional and later changes.

[1] The helpful suggestions of the two anonymous reviewers and of Patrick Honeybone are hereby gratefully acknowledged; remaining shortcomings are my responsibility.

Another essential change in Gmc, which obscured the mechanism behind Verner's Law, was the change in how prosodic emphasis was realised. IE had a pitch accent, with high tone on whatever syllables were stressed, whereas Gmc developed dynamic stress on the root syllable of all words. Dynamic stress has a number of phonetic correlates besides higher pitch: more air from the lungs, greater loudness, and longer duration (Ladefoged 2005: 20-25). As Verner's Law was triggered by stress differences, the law must have operated before the fixing of the stress on the root syllable.

The mechanism at work in Verner's Law is phonetic lenition (weakening) in unstressed environments. The term 'lenition' is going to play a major role in this paper, so a definition is provided here: it is traditionally defined as change which involves weakening of segmental strength, such as opening or sonorisation, whereas 'fortition' has the opposite effect (Honeybone 2002: 39-43, 2012). Lass (1995: 177) refers to lenition and fortition as "involving change both in stricture and glottal state", and states that lenition "increases the permeability of the vocal tract to airflow". Voicing is usually treated as an instance of lenition,[2] and stress placement may in fact change the voicing of segments: consider Present-Day English (PDE) <x>, which is pronounced as /ks/ when the stress falls on the preceding vowel (*exit, exercise, execute*), but as /gz/ when the stress falls on the following vowel (*exam, exert, executive*).[3] Verner's Law changes are hence combinative, whereas the changes in Grimm's Law appear to be isolative.

There is no dearth of research on Grimm's Law and Verner's Law, but the present article does not attempt to provide an overview of all or even most of the vast literature on the topic. The best and most comprehensive account to date is that of Iverson & Salmons (2003), and the aim of this paper is to use findings from modern experimental phonetics to throw light on some unresolved issues in their account, especially the processes which defy characterisation as lenition, and the problem of the prime mover. Specifically, it will be argued that the shift from IE pitch to Gmc stress was the first change, which set the changes subsumed under

[2] Lass (1995: 177) comments that it is not entirely clear why changes in glottal state should be grouped with changes in stricture as instances of lenition/fortition, but that "the frequency with which the change voiceless → voiced is a precursor to opening of stricture argues for an essential similarity". He concludes (1995: 178) that "Perhaps the best way to look at lenition/fortition overall is in terms of two strength scales, one of **openness** and one of **sonority**: movement down the first involves decreased resistance to airflow, movement down the second an increase in the output of periodic acoustic energy" (original emphasis).
[3] There is variation among speakers with regard to some of these words, especially *exit*, but the point still stands.

Grimm's Law in motion, introducing aspiration as an active laryngeal feature and causing affrication of the inherited voiceless stops. In using insights from experimental phonetics, this paper continues the work carried out by Ohala (1974, 2003), who searches for phonetic answers to historical phonological problems, connecting phonetics and phonology through elements of physiology and aerodynamics (Ohala 1973, 1983, 1997). Section 2 deals with problems associated with the traditional formulation of Grimm's and Verner's Laws; section 3 examines terms that are relevant to providing a unified account of Grimm's and Verner's Laws; section 4 gives a summary of Iverson & Salmons's exposition; section 5 addresses some aspects of Grimm's and Verner's Laws which remain problematic and proposes a chronology of the changes involved; section 6 summarises my conclusions.

2. Problems with the traditional account

2.1 The original IE/Gmc obstruent inventory

One essential problem pertains to the assumed Proto-Indo-European (PIE) obstruent inventory: as conventionally outlined, it is (thought to be) typologically marked, since it contains two series of voiced stops and one series of voiceless stops, which goes against the typical state of affairs in modern languages (Henton *et al*. 1992).[4]

Competing views have therefore been proposed. Emonds (1972) suggests that it is in fact Gmc which had the most conservative stop system, and that it was the other, 'classical', IE languages which had changed; Emonds's hypothesis appears not to have many adherents at present. The glottalic theory (Gamkrelidze & Ivanov 1973; Hopper 1973), as reported by Salmons (1993), proposes alternative IE and Gmc obstruent inventories, most notably that IE or Pre-Gmc had ejectives *in lieu* of the traditional plain voiced stops (cf. Vennemann 1984: 19; Noske 2012). Ejectives tend to be voiceless, so the 'glottalic scenario' implies that the ejectives may have been phonemically unspecified for voice, and that Grimm's Law entailed their changing from ejectives to plain voiceless plosives. If so, Grimm's Law may be as shown in (3), leaving out the labiovelar consonants: aspiration was non-contrastive, and the key oppositions were hence voiceless vs. ejective vs. voiced.

(3) Grimm's Law:

[4] Besides, the /b/ of the plain voiced series is extremely rare; this problem will not be addressed here, but see Lehmann (1993: 97) for an account of the issued involved.

IE voiceless stops /p t k/ > Gmc voiceless fricatives /f θ x/
IE ejectives /b' d' g'/ > Gmc voiceless stops /p t k/
(IE voiced aspirated stops /b d g/ > Gmc voiced stops /b d g/)

This is not enough, however, to make the proposed inventory unmarked: in their phonological research on modern languages, Henton *et al*. (1992: 78-79, 95) examine stop inventories in a very high number of languages, and consequently suggest the following implicational series of stops: voiceless (unaspirated) > voiced > voiceless aspirated > voiceless ejectives > voiced implosives.[5] None of the proposed IE or Pre-Gmc stop inventories agrees completely with these findings: whether or not ejectives are included, the inventories are somehow marked.[6]

Kümmel (2015: 12), after assessing data from a high number of languages, concludes that "synchronic typology favours 'glottalic' models, but diachronic typology rather contradicts this", and that "the diachronic typology of systemic developments clearly favours the traditional reconstruction of the plosives as against all 'glottalic' models", i.e. voiceless unaspirated stops, voiced stops, and voiced aspirated stops.[7] Moreover, most accounts written within the glottalic framework now assume intermediate changes to the stop inventory between IE and Pre-Gmc, or between Pre-Gmc and PGmc, such that the direct inputs to Grimm's Law were in fact the conventional series of stops, i.e. voiceless, voiced and voiced aspirated stops (e.g. Salmons 1993: 59-61; Vennemann 2006: 131). Iverson & Salmons (1995; 2003: 55, fn. 15) also take the traditional series as their point of departure.

Basing his scenario on observed changes in obstruent inventories, Kümmel (2015) proposes an alternative inventory, i.e. that PIE originally had implosives; these are 'non-explosive'stops: they have ingressive pulmonic airstream and for that reason, there is no release.[8] These implosives changed into simple voiced stops, and the original voiced stops acquired breathy voice, to produce the traditional inventory of voiced stops and voiced

[5] In other words, if a language has only one set of phonemically distinct stops, that set almost always consists of voiceless (unaspirated) stops; if a language has two sets, the voiceless stops will be supplemented by a series of voiced stops, etc.

[6] Noske (2012: 71) believes that with the alternative "model, the typological problems concerning the obstruent inventory have been resolved" as "there are no longer voiced aspirates", but this seems to be merely a result of the model: it is only if we accept that the traditional voiced stops were ejectives that we can re-*label* the traditional voiced aspirates as simple voiced stops. However, ejectives are not much more common than voiced aspirates, so the original problem has not disappeared.

[7] As will become clear, I assume that aspiration was acquired between Pre-Gmc and the onset of Grimm's Law.

[8] Kümmel (2015: 12) calls them nonobstruent stops, but they do have a complete obstruction of the air, so they are more correctly classified as *unreleased* obstruents with ingressive airstream.

aspirated stops (Kümmel 2015: 14), besides the voiceless stops. For these reasons, I shall assume the conventional stop inventory as the immediate input to Grimm's Law.

2.2 Chronology and intermediate stages

Another issue is the internal chronology of Grimm's Law and Verner's Law. Early accounts assumed that Grimm's Law predated Verner's Law, whereas more recent work often states that identical results obtain with any chronology. However, Verner's Law clearly affected voiceless fricatives as a *group*, since PGmc /s/ is found among the affected consonants. Since Gmc voiceless fricatives, with the exception of /s/, arose as a result of the operation of Grimm's Law, it follows that the part of Grimm's Law which affected the IE voiceless stops must have preceded Verner's Law, which then affected all the Gmc voiceless fricatives, regardless of origin.

Vennemann (1984: 20-22) argues that Verner's Law took place before the affrication and spirantisation of the etymological voiceless stops, partly because such a chronology gets rid of the problem of occlusivisation. That is, in Vennemann's chronology, as well as that of e.g. Kortlandt (1985, 1988) and Noske (2012), Verner's Law changed PIE /t/ directly to /d/. However, such a chronology does not explain why Verner's Law seems to have operated on voiceless *fricatives* as a group – in other words, why /s/ should be likewise affected. Besides, the essence of Verner's Law is not stopping, despite Noske (2012),[9] but voicing/lenition in unstressed environments. The traditional scenario is simpler in that it assumes that Grimm's Law operated on all voiceless stops in all environments (except after *s*), and that Verner's Law caused voicing of a subset of the output in certain environments. The alternative chronology, however, has to posit a bifurcating process (Noske 2012: 74-75) in which the voiceless stops were affricated and spirantised only in those context in which Verner's Law did not operate, making Grimm's Law context-sensitive as well.

Concerning the other two Grimm's Law changes, things are less clear, as their chronology may be connected to the issue of possible intermediate stages, especially with respect to the

[9] Noske (2012: 68) additionally finds it problematic that *s* did not undergo stopping. As stated in the preceding, however, the essence of Verner's Law is not stopping, but voicing/lenition, which of course also affected *s*. It could be argued that rhotacism of *z* (< *s*) is in fact a kind of fortition, at least if the product was a tongue-tip trill or tap (the resulting *z* could not stop to a coronal plosive, because it would then have merged with pre-existing /d/).

process that changed the IE voiced aspirates into Gmc plain voiced stops; I will return to this later.

Voiceless aspirated stops have a long history of changing into voiceless affricates and fricatives: Grimm's Law is but one example; Greek *ph* > *f* is another (Allen 1987: 22-26). 'Liverpool lenition' refers to an ongoing process, in which the voiceless aspirated stops /p t k/ in Scouse are undergoing affrication to [pɸ tθ kx], and then spirantisation to [ɸ θ x]; it is reported to depend on e.g. prosody and word position (Honeybone 2007, and references cited there).[10] Affrication and spirantisation of voiceless plosives is also seen in the Second Consonant Shift (SCS), which affected High German, and which changed the then voiceless plosives (< IE voiced stops) into affricates and fricatives, after which the then voiced stops devoiced (Moulton 1954: 33-42).[11] It therefore seems highly probable that the IE voiceless stops were first affricated in Gmc in the first stage of Grimm's Law, and then spirantised. Now, if changes were symmetrical in the voiceless and voiced series, it would seem likely that the IE voiced aspirated stops b^h d^h g^h also underwent affrication (> $b^β$ $d^ð$ $g^ɣ$) and spirantisation (> *β ð ɣ*) before finally stopping to *b d g*; I will return to this in section 5. If so, the last change involving stopping of voiced fricatives is identical to the last stage in Verner's Law (e.g. *ð* > *d*). A possible chronology is given in (4) below; the internal chronology of stages ii and iii is of little consequence if iii entailed affrication and/or spirantisation; if it did not, ii must have preceded iii.

(4) The stages of Grimm's Law (i-iii) and Verner's Law (iv):

i. IE voiceless stops > Gmc voiceless affricates > Gmc voiceless fricatives
ii. IE voiced stops > Gmc voiceless stops
iii. IE voiced aspirated stops > Gmc voiced affricates > Gmc voiced fricatives
iv. IE voiceless fricatives (from i) > voiced fricatives (which merge with voiced fricatives from iii above) > voiced stops

The devoicing in stage ii and the stopping in the last stage in iv are the changes that stand out, defying characterisation as processes of lenition, which brings us to the next point. The chronology of Grimm's and Verner's Laws, and the question of intermediate stages, will be further discussed in sections 4 and 5.

[10] For instance, affricated allophones are found initially, whereas spirants occur word-finally (Honeybone 2007).
[11] Goblirsch (2001) views this process as a consonant shift in itself, and posits different stages of similar shifts for High German, Danish and Icelandic.

2.3 A unified phonetic account

Another problem is that of arriving at a unified phonetic account of the changes covered by Grimm's and Verner's Laws, as they seem to go in opposite directions, whether described articulatorily or in terms of lenition. Articulatorily, Grimm's Law involves affrication, spirantisation, devoicing, de-aspiration (if there were no intermediate stages in the change IE voiced aspirates > Gmc voiced stops) or stopping (if there were intermediate stages), whereas Verner's Law involves voicing and stopping. Under the definition of 'lenition' and 'fortition' given in section 1, affrication, spirantisation, de-aspiration and voicing are processes of lenition, whereas devoicing and stopping are instances of fortition. However, according to Kager *et al.*'s definitions (2007), so-called 'devoicing' is really aspiration (and 'de-aspiration' is a change from long-lag VOT to short-lag VOT). Besides, Lass & Laing (2013: 99 fn. 6) define lenition rather as an "increase of trans-oral airflow", which means that aspiration is in fact lenition, not fortition, because the duration of the complete closure for the plosive is reduced (so also Lass 1995: 178). Additionally, affrication and spirantisation are likely due to the fact that heavily aspirated stops have shorter and less complete closures (Iverson & Salmons 2003: 58) – they can be seen as target undershoot. If this is permitted, all the changes subsumed under Grimm's and Verner's Laws are instances of lenition, except the stopping process.[12]

This raises the question, Is it possible to find one common phonetic mechanism which triggered Grimm's and Verner's Laws? I believe the answer is in the affirmative, but in order to identify this mechanism, we need to arrive at a better understanding of the acoustic-articulatory phenomena involved, i.e. voicing, aspiration, and voice onset time (VOT), as well as of other relevant articulatory and prosodic parameters, such as sub-glottal and trans-oral pressure, duration of closure, gestural timing, stress, etc. These are the topic of the next section.

3. Air-flow, pressure, voicing, aspiration and laryngeal specification

The state of the glottis varies considerably and forms a continuum, from fully closed for a glottal stop to fully open for breathing; the "continuum reflects differing amounts of airflow

[12] In this view, de-aspiration can consequently be defined as either lenition or fortition, which is a problem in so far as it threatens to render 'lenition' vacuous as an explanatory term.

at the glottis" (Henton *et al*. 1992: 72-73; 66, Fig. 1). Transglottal airflow rates thus vary with the type of laryngeal constriction.[13]

Henton *et al*. (1992) conclude that so-called 'voiced aspirated' stops are in fact voiced stops with breathy voice, and are intermediate between aspirated stops and voiced stops.[14] As for the timing of the glottal opening, it is "characterized by an abduction of the vocal cords at the time of the release of the stop closure" (Henton *et al*. 1992: 82), which is a feature they share with voiceless aspirated stops.

"Pressure built up in the mouth depends on air pressure from the lungs and organic pressure at the constriction. The more intense the air pressure, the stronger the organic pressure must be to stop it" (Delattre 1965: 118; cf. Morton 1984: 23-24). This fact has at least two consequences: it is "Hard to maintain voicing during a stop due to air pressure equalizing in the oral and subglottal cavities" (Henton *et al*. 1992: 72, referring to Ohala 1983; cf. Morton 1984: 24-25); and voiced stops have a narrower tongue constriction because "the pharyngeal cavity must expand during closure to keep voicing going", simply because there is a complete closure (Shadle n.d. referring to Westbury 1983).

An articulatory gesture is

> identified with the formation (and release) of a characteristic constriction within one of the relatively independent articulatory subsystems of the vocal tract (i.e., oral, laryngeal, velic). Within the oral subsystem, constrictions can be formed by the action of one of three relatively independent sets of articulators: the lips, the tongue tip/blade and the tongue body. As actions, gestures have some intrinsic time associated with them – they are characterizations of movements through space and over time. (Browman & Goldstein 1989: 69)

It follows that any consonant involves one or more gestures, and that the relative timing of their formation and release may vary; this is called gestural timing. A consonant has three stages: the form/approach stage, the hold stage, and the release stage (cf. Henton *et al*. 1992:

[13] Henton *et al*. (1992: 73) find that aspirated stops have an airflow rate of up to 1,000 ml/s, whereas the rate for stops pronounced with breathy voice is close to 500 ml/s, and that for voiced stops is 120 ml/s.

[14] Breathy voiced stops in Hindi have (1) less activity of the cricothyroid muscle than voiced stops because the vocal folds are slack, (2) a "[m]oderately open glottis (about 50% of that used during aspiration)", (3) a "high rate of oral airflow following release", (4) a quick decrease in subglottal air pressure, and (5) voice present (Henton *et al*. 1992: 80-81); cf. Lisker & Abramson (1964: 403, 418-419).

66). The duration of closure refers to the hold stage and varies systematically for so-called voiced and voiceless obstruents: the closure is longer for the voiceless stops than for their voiced counterparts.

Phonetically, voicing or phonation refers to the vibration of the vocal cords. However, there is a difference between phonetic voice and phonemic voice. Traditionally, the phonemic difference between obstruent pairs such as /t/ and /d/ has been referred to as a difference in 'voice', but in Gmc, phonemic 'voice' does not correlate with phonetic voice. That is, the difference between obstruent pairs in Gmc rarely involves phonation, but rather the closure duration and aspiration (Delattre 1965); the 'voiceless' obstruents have a longer complete closure and are aspirated, whereas the so-called 'voiced' obstruents have a shorter closure and no aspiration. Aspiration in turn refers to spread glottis, i.e. abducted vocal cords, which entails a delay in the onset of the voicing of the following segment: "Aspiration occurs when the open [glottal] state is prolonged past the moment of oral release" (Henton *et al*. 1992: 72).

This difference in how phonemic 'voice' is realised has given rise to a dichotomy between 'voicing languages' (e.g. Romance) and 'aspiration languages' (e.g. Germanic languages except Dutch),[15] which refers to a difference in laryngeal specification, following Lisker & Abramson's seminal article from 1964. The phonetic realisations of laryngeal contrasts vary cross-linguistically. The main acoustic and perceptual cue is voice onset time (VOT), or the time between the release of a stop consonant and the beginning of phonation (vocal cord vibration). Gmc languages seem to have a two-way contrast, voice and aspiration. In Dutch, the voice onset starts simultaneously, or even before, the release, which makes it a (pre)voicing language with "voicing lead" (Lisker & Abramson 1964: 389),[16] whereas in the

[15] I will assume, in agreement with most of the research literature, that (standard varieties of) the Gmc languages are aspirating languages, except Dutch (but see Hunnicutt & Morris 2016: 216). This is not to say that variation is non-existent: a great deal of variation is certainly found within accents of English regarding (pre-)voicing and (degree of) aspiration, for instance in Welsh English (Wells 1982: 388) or Scots (Wells 1982: 409, 413); this synchronic variation may reflect a diatopic and diachronic situation in which the status of aspiration varied, although in some cases it is probably a Celtic interference/substrate effect, and is so explained by Wells. That Gmc languages are aspirating languages is maintained in e.g. Goblirsch (2001) for Icelandic and Danish; Moosmüller & Ringen (2004) for German and Austrian Standard German; Beckman, Jessen & Ringen (2013) for German, English, Danish and Icelandic; van de Weijer & van der Torre (2007) for German and English; Schluter *et al*. (2017) for English. Helgason & Ringen (2008) find that Central Standard Swedish seems to employ a two-way contrast, pre-voicing and post-aspiration, i.e. both [voice] and [spread glottis] are active laryngeal features; the same appears to hold for Southern American English (Hunnicutt & Morris 2016).

[16] The same is true of certain accents of English in Scotland (e.g. those of Aberdeen and Shetland, cf. Hughes, Trudgill & Watt 2012: 133, 163) and elsewhere (e.g. the Scottish-English border, cf. Docherty *et al*. 2011).

other Gmc languages, there is a delay in VOT for both traditional ‘voiced’ (short-lag VOT) and voiceless obstruents (long-lag VOT), making them aspiration languages. Lisker & Abramson (1964: 407) find that “the distribution of [VOT] values is essentially tri-modal, corresponding generally to the ranges centering at -100, +10 and +75 msec” for the traditional ‘voiced’, ‘voiceless unaspirated’ and ‘voiceless aspirated’ stops, respectively.

Linguists have disagreed as to the specification of laryngeal features. Some researchers espouse the Single Feature Hypothesis (SFH) and claim that there is one feature for laryngeal representation, [voice], but they differ in their view of this as a binary feature [±voice] or a monovalent or privative feature [voice] (Kager *et al*. 2007: 42-44). Others find that there are multiple monovalent features (e.g. Iverson & Salmons 1995), and that one of these features is the active one in the different languages, i.e. [voice] for (pre)voicing languages and [spread glottis] for aspiration languages; this is the Multiple Feature Hypothesis (MFH). The MFH is now referred to as ‘laryngeal realism’ (Honeybone 2005: 345), and proponents include Beckman, Jessen & Ringen (2013), Schwarz *et al*. (2019).

In Dutch, [voice] is the active feature, and it thus has e.g. the phonemes /p/ vs. /b/, whereas [spread glottis] or aspiration is the active laryngeal feature in aspirating languages, and voicing is hardly contrastive, which gives /p^h/ vs. /b̥/ (or /p^o/, cf. Honeybone 2005: 332). The findings of Kager *et al*. (2007) strongly support ‘laryngeal realism’; the laryngeal specifications for the three languages examined (Dutch, German and English) are as shown in Table 1 (reproduced from Kager *et al*. 2007: 45).

Table 1. Laryngeal feature specification in three Gmc languages (Kager *et al*. 2007: 45)

	Voicing lead	Short-lag VOT	Long-lag VOT
Dutch	[voice]	[ ]	
German		[ ]	[spread glottis]
English		[ ]	[spread glottis]

Thus, in Dutch and other true voice languages, voiceless consonants lack specification, whereas voiced stops are specified for [voice], which means that the unmarked (unspecified) category is voicelessness. In aspiration languages, the contrast is shown as a [spread glottis] specification for aspirated stops, whereas plain unaspirated stops lack laryngeal specification, making them the unmarked category (Beckman, Jessen & Ringen 2013).[17] The distinction between the SFH and the MFH (or between tradition (i) and tradition (ii) in Honeybone's (2005) terminology) is therefore essential, because it encompasses a crucial difference in what category is unmarked (since changes tend to go in the direction of the unmarked category), and because it carries with it predictions about possible and impossible phonological changes (Honeybone 2005).

Essential characteristics of the larynx have traditionally been identified in terms of the features [voice], [spread glottis] and [larynx height], but another way to represent laryngeal specification has been put forth more recently – Avery & Idsardi's 'Laryngeal Dimensions' (2001). They propose three dimensions of the larynx: Glottal Tension (with the features [slack] and [stiff]), Glottal Width (with the features [spread] and [constricted]), and Larynx Height (with the features [raised] and [lowered]). Voicing languages thus have Glottal Tension as their essential laryngeal specification (and the default feature for obstruents tends to be [slack]), whereas aspiration languages have Glottal Width (and the default feature tends to be [spread]; Iverson & Salmons 2003: 47-48). In any one language, one laryngeal dimension is active, and only "one member of an antagonistic gestural pair is used contrastively in a given system" (Iverson & Salmons: 47). Glottal Width has the antagonistic pair [spread] and [constricted], and in English and German, the phonologically active gesture is [spread]: they thus "contrast [spread] voiceless aspirated stops with laryngeally unmarked lenis stops", though it is possible that "the other member may be invoked as a phonetic embellishment, or 'enhancement', of a contrast" (2003: 47).

The difference between these two representations of phonemic 'voice' or laryngeal specification is very much in focus in Iverson & Salmons's (2003) account of Grimm's Law, which is the topic of the next section. A crucial question is when (Pre-)Gmc went from being a voicing language to being an aspiration language, i.e. when Glottal Tension was replaced by Glottal Width as the active laryngeal specification.

[17] Schluter *et al.* (2017), however, find in favour of the single feature hypothesis, since they obtain the same Mismatch Negativity results in experimental research involving native speakers of English (aspirating language), Arabic (supposedly voicing language), and Russian (true voicing language). Their findings are incompatible with the laryngeal realism paradigm, but support a model that "posits that two-way laryngeal contrasts are represented in long-term memeory in a format that abstracts away from their precise articulatory details" (2017: 23), and that the active laryngeal feature for *all* languages is in fact [-voice] or [spread glottis].

4. ‘Germanic Enhancement’

In essence, Iverson & Salmons (2003: 56) state that the introduction of aspiration in Gmc set the whole shift (Grimm’s Law) in motion in a pull-chain. In other words, rather than simply assuming *a priori* that the voiceless stops in Gmc were aspirated, they see the acquisition of aspiration as an innovation and a “persistent articulatory constraint” (2003: 44, 53 ff.), which they call ‘Germanic Enhancement’.[18] PIE was a voicing language, and the acquisition of aspiration was the result of some change in ‘articulatory setting’ in Gmc speakers (2003: 68).[19] Whatever the nature of this change in setting, it introduced (a) aspiration as a characteristic of the voiceless plosives, and (b) [spread glottis] as an active laryngeal feature. It was this newly acquired aspiration that triggered affrication and spirantisation of the voiceless plosives, upon which the voiced stops “devoice to form a new unmarked series”, i.e. lose their marking for Glottal Tension and become aspirated, and the voiced aspirates “simplify to voiced”, through the “loss of the now superfluous Glottal Width dimension” (2003: 56). In the end, [voice] was removed from the system, and Gmc no longer had Glottal Tension as its essential laryngeal specification, but Glottal Width (2003: 63).

The IE accent was a pitch accent with high pitch, i.e. stiff vocal cords, on stressed vowels. Slack vocal cords entail low pitch and in fact induce passive voicing of obstruents (Iverson & Salmons 2003: 44), especially of laryngeally unmarked fricatives (2003: 48-50). Among the sonorants, of course, Glottal Tension is an active laryngeal feature. Verner’s Law is thus simply passive or spontaneous voicing, the voicing ‘bleeding’ from a preceding *unaccented* vowel;[20] stressed vowels are marked as having [stiff] vocal cords, which inhibit voicing/vocal

[18] Ridouane (2006: 7-8) explains why this is *enhancement*: “According to Keyser & Stevens (2001) spreading of the glottis may serve as an enhancing gesture for the [stiff/slack vocal folds] contrast in English. This enhancement is produced in pretonic, onset-initial position. In Keyser & Stevens’ view: ‘enhancement may take place whenever a given distinction can be made more salient than it might otherwise be’ (2006: 12). In syllable-initial position pretonically, the distinction threatened is that between /p/ and /b/, for example. The distinction between these two stops is only weakly represented in the sound (both /p/ and /b/ being unvoiced, the pre-voicing of /b/ is presumably weakened because of the vocal-fold stiffening in anticipation of the following stressed vowel). Because the distinction between these two series of stops is threatened, it is made more salient and enhanced by the spreading of the glottis for /p/ and thus by extending the voiceless interval into the beginning of the following vowel”.

[19] Iverson & Salmons (2003: 68) see ‘articulatory setting’ as the way in which all the articulators are aligned or ‘set’ in native speakers of a given language; this setting differs between e.g. Dutch, Norwegian and Urdu speakers, and is part of the reason why e.g. Norwegian speakers may be identified as such when they attempt to speak another language.

[20] That is, “glottal vibration ensues automatically with sufficient airflow across vocal folds which are in a neutral state of abduction, as in the case with ordinary sonorants of all types, consonants as well as vowels” (Iverson & Salmons 2003: 50); further, “the phenomenon of ‘passive voicing’ in obstruents can be understood as the extension of spontaneous voicing into a neighbouring segment not already specified for a laryngeal quality. This

cord vibration because of low transglottal airflow (2003: 60); hence Verner’s Law did not take effect when the preceding vowel was stressed (see also Johnsen 2011). Verner’s Law, then, is “not an independent innovation”, nor indeed a ‘law’ (Iverson & Salmons 2003: 44, 59), but the contextual phenomenon of passive obstruent voicing.

Thus, in Iverson & Salmons’s account, there was no stopping of fricatives in the Grimm’s Law changes to IE voiced aspirates, simply because the voiced aspirates did not affricate or spirantise in the first stage – they simply lost their aspiration (Iverson & Salmons 2003: 56). Fricative allophones developed later as a result of ‘passive spirantisation’, which produced voiced fricatives “which contrast with the medial voiceless fricatives in Germanic, i.e. those that escaped voicing via Verner’s Law due to preceding accent” (2003: 58). The voiced fricatives from Verner’s Law do appear as stops in the written record,[21] so it is possible that they merged with the voiced fricatives that arose through passive spirantisation of voiced stops (< IE voiced aspirates), but Iverson & Salmons (2003) do not state this explicitly; this may be the weak point of their account, and I will return to it in section 5.

There is some evidence supporting the claim that Gmc went from being a voicing language in its very earliest stages, to becoming an aspiration language: the failure of Grimm’s Law to take effect when the stops were preceded by *s*.[22] For PDE, Iverson & Salmons (1995) are able

penetration operates rightward from a segment provided with Glottal Tension to a following laryngeally empty one, which, in English […] is any of the lenis obstruents” (2003: 51).

[21] Honeybone (2005: 333) notes that the letters <b, d, g> have “been used to represent more than one kind of phonological segment”, i.e. voiced /b d g/ in voicing languages, and /pº tº kº/ in aspiration languages. This is a natural consequence of the adoption of the Roman alphabet, which was devised for a voicing language. The argument could, however, be extended: the fact that the outputs of Verner’s Law (and of the development of the voiced aspirates for that matter) appear as <b, d, g> need not mean that the sounds they correspond to were stops.

[22] Besides, Kager *et al*. (2007) argue that the difference in laryngeal specifications for voicing and aspiration languages has consequences for predictions regarding acquisition errors to do with devoicing and voicing in L1 children: children “tend toward the unmarked value” (Kager *et al*. 2007: 46). The unmarked values are /p t k/ for voicing languages, /b̥ d̥ g̊/ for aspiration languages. Specifially, the MFH predicts that children acquiring voicing languages should show errors involving devoicing (Kager *et al*. 2007: 47), whereas children acquiring aspiration languages, on the other hand, should show de-aspiration errors (*ibid*.). The predictions of both hypotheses are reproduced below (from Kager *et al*. 2007: 47).

	Voicing language	Aspiration language
SFH:	/b/ → [p]	/b̥/ → [p^h]
MFH:	/b/ → [p]	/p^h/ → [p]

It is the laryngeal error predictions of the Single Feature Hypothesis, as well as those of the Multiple Feature Hypothesis for *voicing* languages (and not for aspiration languages), which seem to be borne out in the Grimm’s Law change involving the devoicing of IE voiced stops (/b d g/) to Gmc voiceless stops (/p t k/), i.e. one of the changes which stand out as fortition processes. In both models, this change involves the simple deletion of the laryngeal specification [voice] in a voicing language, i.e. a change towards the unmarked consonant. This to give a unified account of both the lack of aspiration of voiceless stops after /s/ and devoicing of sonorants after voiceless obstruents, under the assumptions (a) that the laryngeal feature in English is [spread glottis], (b) that the feature [spread glottis] may be shared by obstruent-initial consonant clusters, and (c) that [spread glottis] has a constant temporal duration. Only the lack of aspiration after /s/ will be considered in this context. In the words of Beckman, Jessen & Ringen (2013: 267), "since the peak of glottal opening for a voiceless stop occurs relatively late in a single stop, but in a fricative coincides with the beginning of oral constriction, […] the vocal folds will be coming together for voicing earlier" in the clusters /sp/, /st/, /sk/ "than in a singleton stop, and hence there will be no aspiration of the stop". The fact that Grimm's Law failed to apply when the stops in question were preceded by *s* must be taken as relatively certain proof that aspiration, i.e. [spread glottis], had become an active laryngeal feature by the time Grimm's Law started. At the same time, aspiration of the voiceless stops should not be assumed *a priori*, for PIE or Pre-Gmc, as PIE is believed to have been a voicing language, in which [spread glottis] would not have been an active laryngeal feature.

5. Remaining problems

5.1 The voiced aspirates and fricative stopping

It was noted in section 2.2 that if changes in the so-called 'voiceless' and 'voiced' series are parallel, the voiced aspirates must also have been affricated and spirantised before stopping. Such a scenario is envisaged by Moulton (1954: 38-39), because it seems in fact to entail a less complicated process towards the final attested results than does simple de-aspiration. The last two stages of this process are identical to Verner's Law, and the terminal products of both processes merged. In Iverson & Salmons's account (2003: 56), however, the IE voiced aspirates were not affricated or spirantised, and then stopped, but simply lost their aspiration. Thus, the stopping process which stubbornly resists characterisation as an instance of lenition is a pseudo-problem. Passive spirantisation was a secondary change and merely allophonic; the main allophone was always [d].

appears to support the hypothesis that the Gmc languages were still voicing languages in their very earliest stages, but that they later became aspiration languages. This does not refute Iverson & Salmons's hypothesis: even if aspiration was acquired phonetically very early in Gmc and set Grimm's Law in motion, it may not have become a distinctive (i.e. phonemic) feature until much later. To use a parallel: Gmc languages still have phonetic voicing, but its distinctiveness and application vary greatly.

Moulton's account (1954) is an interesting alternative to Iverson & Salmons's view that the change to IE voiced aspirates consisted of simple de-aspiration. Moulton, basing his claims on a thorough assessment of all the earliest attestations of Gmc, finds that voice held primacy over occlusion type as a distinctive feature in the earliest Gmc, which entails that the voiced fricatives were allophones of the voiced stops: /t/ and /θ/ vs. /d/ [d, ð]. Later, occlusion type became the primary distinctive feature, which means the voiced fricatives were allophones of the voiceless fricatives: /t/ and /d/ vs. /θ/ [θ, ð]. Even later, aspiration seems to have acquired primacy, certainly in OHG. If this is permitted, the end product of the changes to e.g. IE /d^h/ may in fact have been [ð] (not [d]), which later fell in with /d/ <d>, *only because voiced fricatives were allophones of voiced stops in early Gmc*; i.e. the allophone [ð] of /d/ merged with the main allophone [d], which in fact agrees with Iverson & Salmons's account. Such a scenario would also make the stopping process in Grimm's/Verner's Law a pseudo-problem: it would merely be the result of the system of allophones and phonemes.

However, Verner's Law did entail fricative stopping, and there have been later processes of stopping of the dental fricatives in most Gmc languages, so some discussion of the issue is in order. Fricative stopping in general is not common, but TH-Stopping has taken place historically in all the Gmc languages except (standard) English and Icelandic, and is happening in accents of PDE, e.g. in Liverpool (Honeybone 2007), New York City and Jamaica (Wells 1982: 515-6, 565-6, 575); besides, many non-standard varieties of English have lost the dental fricatives (accents of Scots, accents of Irish English), possibly as a substrate effect (Wells 1982). Cross-linguistically, dental fricatives are rare, 'unnatural' or marked (Wells 1982: 96), simply because they are difficult to produce. Stopping of other fricatives is very rare, but does occur in the speech of small children.[23] This suggests that stops are easier to pronounce for children because a complete closure does not require the fine-motor skills necessary for fricatives, and that stopping may in fact be target overshoot: a complete closure, instead of a considerable narrowing, is made between the upper and lower articulators.

[23] In L1 acquisition, children acquire stops before continuants, and L1 acquisition errors include fricative stopping: "There is a lot of variation in the chronology of stopping. Stopping of /f/ is prevalent in children between 2;00-2;06 years and is typically eradicated by 3;00 years. […] stopping of its voiced counterpart /v/ persists a little longer, until around 3;06 years. […] Finally, stopping of the dentals /θ/ and /ð/ may persist until 5;00 years of age." (https://www.sltinfo.com/phon101-stopping/)

Iverson & Salmons (2003) and Moulton (1954) argue cogently for their hypotheses, and it is difficult to determine which provides the more likely account. What the two accounts have in common is the consequence, namely that the development of the IE voiced aspirates in Gmc did not involve stopping *per se*. The later processes of TH-Stopping are not directly relevant to the topic discussed here, but stopping in Verner's Law is: they all seem to be adequately explained by markedness and language acquisition research as articulatory simplification. It is also possible, as outlined in the preceding, that the voiced fricatives resulting from Verner's Law merged with those arising from passive spirantisation of early Gmc voiced stops, for which the main allophones were stops. Now, if the IE voiced aspirates did not undergo affrication and spirantisation, the chronology and nature of Grimm's Law must be revised, as in (5).

(5) The stages of Grimm's Law (i-iii) and Verner's Law (iv)

i. IE voiceless aspirated stops > Gmc voiceless affricates > Gmc voiceless fricatives
ii. IE voiced stops > Gmc voiceless stops
iii. IE voiced aspirated stops > Gmc voiced stops (> allophonic voiced fricatives)
iv. IE voiceless fricatives (from i) > voiced fricatives (also from iii) > voiced stops

5.3 Devoicing

A number of aspects regarding stops and voicing emerge from aerodynamic and physiological research: a crucial finding is that it is in fact difficult to maintain "voicing during a stop […] because the air flowing through the glottis accumulates in the oral cavity, causing oral pressure to approach subglottal pressure", and then "the air flowing through the glottis gradually diminishes and voicing is extinguished" (Ohala 1983: 194).

Moreover, a number of factors affect voicing and VOT: duration, stress, word/syllable position, and place of articulation. With respect to duration, Ohala (1983: 195) finds that long stops tend to be devoiced, whereas short stops become voiced (Ohala 1983: 195). As for stress, "Main stress affects the duration of voicing in stops. The physiological concomitants of stress include increased respiratory muscle activity, resulting in greater subglottal pressure", according to Henton *et al.* (1992: 79), who also find that stops have different acoustic qualities in different word or syllable positions, and that final stops tend to be voiceless (1992: 80). Yao (2009) concludes that VOT may be affected by *linguistic* factors such as speaking rate (shorter VOT with increased speech rate), the following vowel (longer VOT before high vowels, and longer VOT when the consonant is followed by a vowel), utterance position (longer VOT in final position), and place of articulation (longer VOT the further back the consonant is pronounced), as well as by *extra-linguistic* factors such as age (older speakers have shorter VOT) and sex (females have longer VOT).[24] Evidently, voicing and VOT are unstable features that depend on a number of variables (cf. Iverson & Salmons 1995; Beckman, Jessen & Ringen 2013).

As for typological facts on stops, Henton *et al*. state very clearly that all languages have stops (1992: 65) and that all languages have voiceless stops (1992: 79).[25] If so, the process IE voiced stops > Gmc voiceless stops may also have been systemically conditioned to supply voiceless stops at a stage when none existed,[26] and also to avoid merger between the inherited IE voiced stops and the new voiced stops from IE voiced aspirates.[27] Iverson & Salmons see "demurmuring" and devoicing as chain-shift effects of spirantisation (2003: 58).

5.4 A Gmc consonant shift cycle?

Iverson & Salmons explicitly see Grimm's Law as a chain-shift (2003: 69). Certainly, Grimm's Law, Verner's Law and the SCS instantiate certain repeat changes: the SCS affrication and/or spirantisation of voiceless plosives and the subsequent devoicing of voiced plosives are identical to two of the processes in Grimm's Law, i.e. stages i and ii in (5) above (cf. Goblirsch 2001). What emerges is a consonant shift cycle, laid out in (6), with a low number of recurring processes: de-stopping and stopping, de-aspiration and aspiration; it appears to involve lenition mostly, but with entry points for stops in the final stages.[28]

(6) a. Voiceless aspirated plosive > voiceless affricate > voiceless fricative > voiced fricative > voiced plosive > voiceless plosive

[24] Similar findings are reported by Ladefoged (2005: 52-53, fig. 6.3), Henton *et al*. (1992: 79-80), and Wells (1905: 526). If these phonetic facts are applied on the pre-Gmc obstruent inventory, one might venture to suggest that Grimm's Law started in final consonants: aspirated voiceless stops affricated and spirantised, and voiced stops devoiced; the process may have started with the velars, and young women led the way.

[25] In Ruhlen's study (1975) of 706 languages, only 4 had voiced stops but not voiceless stops, and Henton *et al*. show that most languages have 'voiceless' and 'voiced' stops (1992: 67, Table1; 73).

[26] A related process seems to be affecting Scouse: the voiceless aspirated stops are affricated and spirantised, whereas the dental fricatives are undergoing stopping; Honeybone (2007) ascribes the latter to interference from Irish English – which is likely – but it is interesting nonetheless that the two processes should be going on at the same time.

[27] See also Noske (2012) for an account of the Grimm's Law chain-shift within Contrast Preservation Theory.

[28] If we allow, for the sake of argument, that Grimm's Law of IE voiced aspirates entailed affrication, spirantisation and stopping, the last stage is identical to Verner's Law (and may have been the same process). This cycle would be: Voiced aspirated plosive > voiced affricate > voiced fricative > voiced plosive > voiceless plosive.

b. Voiced aspirated plosive > voiced plosive > voiceless aspirated plosive > voiceless affricate > voiceless fricative > voiced fricative > voiceless/voiced plosive

If the majority of the sound-changes observed in Grimm's Law and Verner's Law are processes of lenition, the question is why stops are produced. The answer is probably the same as that provided for devoicing in the preceding section: all languages have stops (Henton *et al*. 1992: 65), and so stops simply tend to be supplied in cases where changes have left the system without plosives. Stops may also be the result of target overshoot and articulatory simplification (of fricatives).

5.5 The prime mover

Some questions still remain unanswered: Which was first, the accent shift or the introduction of aspiration? What was the change in articulatory setting?

Logically, the shift in stress *placement* must have postdated Verner's Law, since the latter depends on the IE variable stress; the same is not true of the shift in prosodic emphasis itself, i.e. the change from IE pitch-dominant prosody to Gmc dynamic stress prosody. It is crucial to distinguish between the stress shift and the stress *placement* shift; they are not the same (cf. Iverson & Salmons 2003: 65). The stress/prosodic shift was a prosodic revolution: Gmc went from marking prosodic importance by means of high pitch (stiff vocal folds) to marking such importance by means of dynamic stress, whose phonetic correlates are manifold, e.g. greater respiratory effort, longer duration, greater loudness and intensity, and higher pitch. The stress *placement* shift entailed a change from lexical, 'free' stress to fixed stress on the root syllable of all words (barring prefixes).[29] It would not be surprising if two such crucial changes would have phonetic consequences; moreover, there may have been overlap between the two systems for some time.

The Gmc stress shift may have been more directly 'involved' in Grimm's Law than has been assumed, as it caused a "considerable disturbance in the coördination of the factors of speech" (Wells 1905: 524). Gestural co-ordination may in fact be disturbed with increased speech rate, which often follows for unstressed syllables: in languages with isochronous stress, stressed

[29] Quoting Halle (1997), Iverson & Salmons state that "default locus of accentuation in Indo-European is word-initial, so that removal of lexically marked accent would automatically result in the observed Germanic pattern" of stress on the root syllable of all words (2003: 64).

syllables come at roughly equal intervals, even in natural speech, and so unstressed syllables are spoken at a greater speed. This suggests that Grimm's Law may have been a co-articulation phenomenon. There is some research on gestural timing in relation to aspiration and VOT. Ladefoged & Cho (2001: 7-8) suggest

> that there is a phonetic parameter, which we will call Articulatory VOT, definable in terms of the difference in time between the initiation of the articulatory gesture responsible for the release of a closure and the initiation of the laryngeal gesture responsible for vocal fold vibration.

Lending support to Lisker & Abramson's conclusions (1964: 422), Ridouane (2006) finds that "it is the timing of laryngeal and supralaryngeal articulations that control aspiration rather than the laryngeal gesture per se" (2006: 5); further, that "aspiration is not a function of glottal opening per se, but rather a function of the degree of glottal opening at stop release" (2006: 6); and finally, that there is "temporal alignment between laryngeal and supralaryngeal gestures" (2006: 7). In other words, there has to be co-ordination between an articulatory (supra-laryngeal) gesture aiming at opening the closure and a laryngeal gesture aiming at initiating phonation, and they do not always co-incide perfectly, causing a delay in VOT, the magnitude of which depends on the degree of spread glottis.[30] It is possible that the Gmc stress shift seriously affected this gestural timing, especially after the introduction of aspiration as an active laryngeal feature, and that the shift in how prosodic emphasis was realised in fact *was* the prime mover and is identical to the change in 'articulatory setting' proposed by Iverson & Salmons (2003: 68). The acquisition of aspiration on voiceless plosives may in fact have been accompanied by a parallel development of aspiration on the original PIE voiced stops, as in Kümmel's view (2015: 14), differentiating the latter from the 'new' PIE voiced stops (< implosives); this would produce the three series of voiceless aspirated plosives, voiced aspirated plosives and voiced plosives as the direct input to Grimm's Law.

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[30] Ridouane (2006: 7) elaborates: "The definition proposed identifies an articulatory continuum (spreading of the glottis and the arytenoids cartilages) that corresponds to a relatively stable region in the acoustic output (aspiration noise generated following the release). During the 50-odd ms following the release, the glottis moves toward a configuration appropriate for the voicing of the following vowel. In this time interval, aspiration occurs without glottal vibration since the glottal spreading inhibits glottal [vibration]. Spread glottal opening is the articulatory definition of the feature and aspiration noise duration the acoustic definition. It is not clear, however, how should [*sic*] the temporal alignment between laryngeal and supralaryngeal gestures (necessary for the production of aspiration) be represented within this definition. As shown above, glottal opening per se is not enough to account for aspiration."

In an attempt at establishing a chronology of changes, I therefore submit that the shift from IE pitch-dominant prosody to Gmc dynamic stress prosody was the very first change to affect Gmc, but that the stress placement remained, as required by Verner's Law, and possibly the high tone also. In other words, the earliest Gmc may have developed dynamic stress, but kept the IE pitch differences for some time, realised as high tone on stressed syllables. As stated before, the "physiological concomitants of stress include increased respiratory muscle activity, resulting in greater subglottal pressure" (Henton *et al.* 1992: 79). This increased respiratory effort may have been the direct reason for the acquisition of aspiration, which crucially triggered affrication of the voiceless stops and hence set Grimm's Law in motion.[31] The chronology would thus be as in (7).

(7) IE pitch > Gmc stress (= increased respiration) > aspiration > affrication, etc.

Verner's Law is often explained almost as an exception, i.e. as voicing only in a certain position and only with a certain stress placement. Is it possible that Grimm's Law depended on these variables too, i.e. the position of the obstruent and the stress placement? In such a scenario, the shift in prosodic emphasis (tone > dynamic stress) caused Grimm's Law changes, in so far as the changed realisation of prosodic emphasis produced new obstruent allophones depending on a number of factors: the consonants' position,[32] the presence/absence of stress on the syllable to which the obstruent belonged and hence the speech rate, the presence of stress on the preceding or following vowel, (the nature of) any preceding/following consonants, etc. With regard to laterals and preceding or following stress, Scobbie & Wrench 2003: 1872) found that "Word-medial intervocalic /l/ was also consonantal preceding stress, but following lexical stress some vocalised […] forms were found". Thus, it may be that the consonantal gesture is reduced in certain environments, i.e. after lexical stress.

There is also a connection between pitch accent high tone and obstruents. Ohala (1973: 6) explains that "a high position of the tongue creates a slight pull on the larynx which is translated into increased vocal cord tension. This results in the widely-noted slightly higher

[31] Vennemann (1984: 20) also sees the spirantisation of the voiceless aspirated plosives as the most characteristic of the Gmc sound-changes: "Sie nenne ich die Urgermanische Lautverschiebung, da sie für das Germanische als vor allem anderen charakteristisch angesehen wird". It is implied that it was the first stage in Grimm's Law (although chronologically, Vennemann puts Verner's Law before Grimm's Law).

[32] For instance, Honeybone (2007) shows that in Liverpool lenition, affricated allophones are found word-initially, whereas spirants occur word-finally.

average pitch for high vowels [i, u] and slightly lower pitch for low vowels [æ, a, ɔ]", but also that "the vocal cords are stiff during the production of voiceless obstruents and are slack during voiced obstruents" which results in "pitch variations accompanying voiced and voiceless obstruents" (1973: 7). Ohala also finds that "Comparing the fundamental frequency after the release of the [b], [p], [pʰ], it is obvious that the pitch is a little higher for the voiceless stops [p] and [pʰ], than it is for the voiced stop [b]" (Ohala 1978: 365; cf. Iverson & Salmons 2003: 44).

I believe that Iverson & Salmons's proposed change in 'articulatory setting' corresponds to the shift from pitch stress to dynamic stress, and that if the Grimm's Law changes were part of a unified process, that process may have been increased respiratory effort and heightened sub-glottal pressure, which would cause an increase in transglottal and trans-oral airflow. Such a change would turn (a) voiceless stops into aspirates, (b) voiceless and voiced aspirates into affricates (> fricatives), and (c) voiced plosives into devoiced plosives, because the heightened pressure would extinguish voicing sooner (Ohala 1983: 194).[33] Alternatively for (c), voiced plosives might become breathy ones, which might be re-interpreted as voiceless aspirates, as they have certain phonetic characteristics in common, including a higher rate of oral airflow, more abducted glottis and a rapid drop in subglottal pressure (Henton et al. 1992: 80-2). This, in essence, is Grimm's Law. The change that is not explained is that affecting IE voiced aspirates if they did not affricate; Iverson & Salmons (2003: 56) propose that they simply lost their aspiration because it was redundant in a system specified for Glottal Width.

The phonetic arguments submitted in the preceding are supported by systemic arguments. It is likely that the voiceless aspirated plosives changed first, due to the acquisition of aspiration in Gmc. The moot point is stage ii, i.e. whether the IE plain voiced stops changed next, or the IE voiced aspirates. If the voiced aspirates changed first, losing their aspiration, this would leave the inherited plain voiced plosives in danger of merging with the new voiced plosives, and this might have contributed to the devoicing of the IE voiced stops, which may have been helped by the physiological fact that voicing is hard to maintain in stops. Alternatively, the voiced stops devoiced first in order to supply voiceless plosives to the system after stage i.

[33] In addition to the natural pitch difference between high and non-high vowels noted in the preceding, there was phonemic high pitch on stressed vowels in IE. Stiff vocal cords and high pitch on accented vowels in IE had an effect on stops, inhibiting voicing (Iverson & Salmons 2003: 44). It is possible that stiff vocal cords for stressed vowels also caused devoicing of following obstruents (Iverson & Salmons 2003: 66).

Such chain-shift arguments find support in the changes of the SCS, in which the voiceless plosives affricated and/or spirantised first, upon which the voiced stops devoiced, and secondly in the seemingly universal requirement that languages must have voiceless stops. The changes to IE voiced stops and IE voiced aspirates may equally have been more or less simultaneous. In fact, stages i-iii may all have been simultaneous,[34] but stage iv (Verner's Law) must have taken place after the voiceless plosives had spirantised.

6. Conclusion

This paper has attempted to identify the one common phonetic mechanism that would trigger the changes observed in Grimm's Law. I agree with Iverson & Salmon (2003) that the acquisition of aspiration in Gmc, and hence of Glottal Width as the primary laryngeal specification, was the change that set the Grimm's Law changes in motion. Aspiration of the voiceless plosives induced affrication and spirantisation, because of the shorter and weaker closure for heavily aspirated stops. This was followed by devoicing of the IE voiced stops, either for systemic reasons – to supply voiceless stops to the system – or for phonetic reasons – because voicing in plosives is difficult to maintain. Finally, the voiced aspirates lost their aspiration, possibly to supply the system with voiced stops, or because aspiration became redundant when Glottal Tension gave way to Glottal Width.

However, Iverson & Salmons (2003: 68) propose that the acquisition of aspiration was the result of some change in articulatory setting, which was thus the prime mover. I have suggested here that the prime mover may have been the widely-noted shift in prosodic emphasis, from IE high pitch on stressed vowels, to Gmc dynamic stress, with its phonetic correlates including longer duration, as well as heightened respiration, intensity and pitch. This prosodic shift may have resulted in increased respiratory effort and heightened sub-glottal pressure, which would cause an increase in transglottal and trans-oral airflow. In turn, increased pressure and airflow would induce aspiration.

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[34] In my examination of that other famous chain-shift, the Great Vowel Shift in English, I conclude that the changes to the high and high-mid long vowels were likely simultaneous (Stenbrenden 2016).

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