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# The phonetics and phonologization of Verner's law

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Verner's law dictates that the Proto-Germanic voiceless fricatives became voiced, except in initial position and immediately after the lexical accent. This paper outlines the phonetic basis for the voicing and its exceptions. It is argued that laryngeal coarticulation between sonorants and fricatives will bring about voicing. The laryngeal settings for an accented vowel, however, are more similar to those of a fricative, making coarticulation less likely. The coarticulatory voicing of fricatives became phonologized when the Germanic accent was retracted to the initial syllable.

## 1. Introduction[1]

1.1. The main focus of historical linguistics and phonological theory is ultimately the same: *sound change* (Ohala 1993a:155). Whereas historical linguistics is predominantly concerned with establishing in a descriptive manner which sound changes have occurred, phonological theory attempts to build cognitive models that are able to synchronically derive sound change through online computation.

1.2. An enterprise that has recently seen a flourishing revival is the attempt to uncover the basis and origin of sound change, and to what extent phonological theory can be relieved of the need to provide a synchronic account of the output of diachrony (Blevins 2004). Under this approach, sound change is analyzed as being rooted in phonetics, through the inevitable workings of phonological implementation – *articulation* – and phonological interpretation – *perception* (Ohala 1993ab).

1.3. Sound change occurs through the following scenarios (Ohala 1993ab):

a) The listener misperceives or misinterprets the acoustic signal.
b) The speaker coarticulates phonological segments, and the listener either fails to compensate for it or overcompensates for it.

In both cases, sound change occurs as a misanalysis on the side of the listener, but scenario (b) posits a direct articulatory basis for the misanalysis. Depending on the sound change under scrutiny, either scenario can be invoked as the more plausible (Ohala 1993ab).

1.4. It will be shown in the following sections that scenario (b), assuming *coarticulation*, is the more likely origin of the sound change under investigation here: Verner's law.

## 2. Verner's law

2.1. According to Verner's law (Verner 1877:114), the Proto-Germanic voiceless fricatives [φ, θ, χ, s] became voiced fricatives [β, ð, γ, z] when adjacent to a voiced sonorant, *except*:

a) In initial position
b) Immediately following the lexical accent

2.2. Following the enterprise outlined in 1.2., the focus of this paper is what the phonetic basis of Verner's law is. How this law can be formally captured in a synchronic phonological model is another question that will not be addressed here.[2]

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[1] I would like to thank Juliette Blevins and Keith Plaster for valuable comments.

2.3. The specific questions that will be treated in the following are:

a) What is the basis for the fricative voicing?
b) Why did the voicing target only fricatives?
c) How can the exceptions in 2.1. be accounted for?
d) How did Verner's law become phonologized?

## 3. Voicing

3.1. The voicing process in Proto-Germanic is an instance of *lenition* (d'Alquen 1988:94, Garrett/Hale 1993, Ramers 1994:295, 1999:38, Iverson/Salmons 2003:49ff.). The term *lenition* encapsulates many phenomena, but what is relevant for us is that voicing is one of the more standard lenition processes (Hock 1991:81, Lavoie 2001:8, Kirchner 2004:313, Blevins 2004:145f.). Regarding the phonetic origin of voicing lenition, there are two different approaches in the literature. One relies on the interplay between duration and perception, the other focuses on the articulation. They are both outlined in the following.

3.2. A key characteristic of lenition is a decrease in duration of the lenited segment. Based on articulatory data showing that voiced obstruents are shorter than voiceless obstruents (Lisker 1957:43, Crystal/House 1982:710, 1988:1555f.), and perceptual data showing that a shortening of voiceless obstruents leads to the percept of voiced obstruents (Lisker 1957:45f., Cole/Cooper 1975:1281ff.), some suggest that voicing lenition occurs when the listener misinterprets the shortened duration of a segment as intended voicing (Lavoie 2001:107, Blevins 2004:147).

3.3. Another key characteristic of lenition is a reduction in the degree of constriction in the articulation of a lenited segment, as in /apa/ > /aφa/ (Kirchner 2004:313). In these cases, the articulatory target of a segment has been undershot. In the example of /apa/ > /aφa/, this means that the complete labial closure in /p/ has not been reached, leading to the incomplete closure of /φ/. Since its neighboring segments have no complete labial closure either, such a reduction makes the lenited segment more similar to its surrounding environment. As a result, lenition can be analyzed as *coarticulation*. Voicing lenition, as in /apa/ > /aba/, is therefore analyzed as a coarticulation phenomenon, since voicing in intervocalic obstruents arises through laryngeal coarticulation (Westbury/Keating 1986:152, Kirchner 2001:44).

3.3. The main difference between the two approaches above is that under the former, the voicing is imagined by the listener, whereas in the latter, the voicing is physiologically real. Since the voicing lenition became phonologically implemented by Verner's law, this means that under the former approach, the sound change emerges through misinterpretation by the listener (1.3.a), whereas under the latter approach, the sound change emerges as the listener fails to compensate for the coarticulatory voicing produced by the speaker (1.3.b).

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[2] For such approaches, see Ramers 1994, 1999, Page 1997, Calabrese/Halle 1998, Holsinger 2000, Iverson/Salmons 2003, Halle 2003, and Petrova 2004.

## 4. Voicing of obstruents in Germanic

In Proto-Germanic, only the voiceless fricatives undergo voicing. The voiceless stops [p, t, k] remain unaltered. A choice between the two approaches to voicing lenition outlined in section 3 above should largely be made on the basis of how well it can account for this fact in Proto-Germanic.

### *Misperception*

4.1. A shortened voiceless stop is perceived by listeners as a voiced stop (Lisker 1957:45f.,), showing that closure duration is an important cue to the voicing quality of a stop. If a decrease in duration is the main reason why voicing lenition occured in Proto-Germanic, the same should apply to fricatives. In perception studies, however, the closure duration of fricatives is seen to play a very small role for the perception of voicing (Jongman 1989:1724, Stevens et al. 1992:2997).

4.2. It is clearly relevant to the different treatment of stops and fricatives in Proto-Germanic that the language had no voicing distinction in fricatives, but did in stops: /b d g – p t k/ (Vennemann 1984:7f.). Under a misperception approach to voicing lenition, however, this fact should make the voiceless stops /p t k/ *more* prone to undergo lenition than the voiceless fricatives, since a listener is more likely to misperceive segment X as segment Y if segment Y already exists in the language (Blevins 2004:154, 2006:128).

4.3. In sum, then, a misperception approach to voicing lenition in Proto-Germanic faces difficulties in accounting for why it only targets fricatives.

### *Coarticulation*

4.4. In a voicing process such as Verner's law, the end result is a change in the laryngeal settings of the fricative. Under a coarticulation approach, the relevant focus is therefore how the articulation of stops and fricatives differ from each other in terms of their laryngeal settings.

4.5. Let us recapitulate the facts of Verner's law: Voiceless fricatives are targeted by voicing lenition, voiceless stops are not. The trigger of the voicing is an adjacent sonorant (2.1.). The question is therefore why a sonorant affects a voiceless fricative relatively greater in its laryngeal settings than it affects a voiceless stop.

4.6. Voiceless fricatives differ articulatorily from voiceless stops in being produced with a larger glottal spread and with higher longitudinal tension of the vocal folds (Hirose/Niimi 1987:386f., Löfqvist et al. 1989:1318ff., Vaux 1998, Stevens 1998:381). A sonorant under modal voicing is produced with a narrow glottal spread and little vocal fold tension (Hewlett/Beck 2006:274ff.). As a result, there is a greater distance in the laryngeal settings between a sonorant and a voiceless fricative than between a sonorant and a voiceless stop.

4.7. The likelihood of lenition increases the greater the articulatory distance is between two segments, since it requires more effort to reach the designated targets (Kirchner 2004:323f.). It is therefore expected that the laryngeal targets for a voiceless fricative are more likely to be undershot in this position than for a voiceless stop. Since a voiced fricative is produced with a smaller glottal spread and with less longitudinal tension of the vocal folds (Löfqvist et al. 1989:1318, Stevens 1998:480), it follows that undershooting these laryngeal targets in a voiceless fricative might lead to voicing.

4.8. An important fact about coarticulation is that it varies from language to language and tends to be sensitive to other phonological facts of the language. More specifically, the degree of coarticulation tends to be greater along non-contrastive dimensions, as when a language with few vowels has more vowel-to-vowel coarticulation than a language with many vowels (Manuel 1999:184ff.).

4.9. As mentioned above in 4.2., voicing was contrastive in stops, but not in fricatives, in Proto-Germanic. Under a coarticulation approach, it is therefore expected that there will be less coarticulatory voicing in stops than in fricatives, since voicing is a contrastive dimension for stops. This is corroborated by a cross-linguistic typological study of lenition, where it is found that lenition very rarely leads to positional neutralization of segments, showing that lenition is phonologically constrained (Gurevich 2004:6ff.).

4.10. In conclusion, there are two facts of coarticulation that add support to a coarticulation explanation of voicing lenition in Proto-Germanic. First, voiceless fricatives are more likely to undergo coarticulatory voicing due to their extreme laryngeal settings. Second, the voicing contrast in stops, and the lack of voicing contrast in fricatives, lead us to expect less coarticulatory voicing for stops than for fricatives.

## 5. Directionality

5.1. For any coarticulation approach, the direction of coarticulation is important. Under Verner's law, it was concluded above in section 4 that a voiceless fricative undergoes coarticulatory voicing with an adjacent sonorant. The question is therefore whether the fricative is primarily affected by a preceding or by a following sonorant.

5.2. In studies of sequences of vowels and fricatives, it has been observed that voiceless fricatives are affected by the voicing of a preceding sonorant more than by a following sonorant (Stevens et al. 1992:2986, Hoole 1999:298). In a $V_1CV_2$ sequence, then, the laryngeal setting leading to voicing in the fricative C is more likely to be carried over from $V_1$ than to be anticipated by $V_2$.

5.3. The apparent 'lagging' effect of this laryngeal setting is supported by phonological facts in other domains. In terms of laryngeal articulation, the setting that allows or inhibits voicing in an obstruent is partly determined by the longitudinal tension of the vocal folds (Löfqvist et al. 1989:1319). The longitudinal tension of the vocal folds is also responsible for raising the pitch of a sonorant (Atkinson 1978, Löfqvist et al. 1989:1320, Stevens 1998:41, 73, Hewlett/Beck 2006:269). In the typologically common phonological process of pitch spreading, there is an observable asymmetry in that the spreading as a rule is carry-over and not anticipatory, showing that tone targets tend to be realized late (Hyman 2007:19).

5.4. As just mentioned, voiceless obstruents are produced with longitudinal tension of the vocal folds. Since pitch raising is controlled by the same mechanism, we expect voicelessness and pitch raising to interact. Numerous articulatory studies show that the pitch is higher immediately after a voiceless obstruent than after a voiced obstruent (Hombert et al. 1979:39ff., Löfqvist et al. 1989:1318f.). Voiceless obstruents do not, however, have the same effect on an immediately *preceding* sonorant (Mohr 1971:71, Gruenenfelder/Pisoni 1980:517ff.).

5.5. In conclusion, we see that the laryngeal setting that is predominately responsible for allowing voicing in a fricative and raising the pitch commonly carries over into a following segment, regardless whether the acoustic effect of that is a change in obstruent voicing or in pitch. This is perhaps not so surprising when we know from clinical experiments that the

cricothyroid muscle, which determines the longitudinal tension of the vocal folds (Löfqvist et al. 1989:1315), is the slowest intrinsic laryngeal muscle, needing 30-45ms to reduce its tension by half (van Lunteren/Strohl 1988:98f.).

## 6. Exceptions to voicing

6.1. We have now provided the answer to question a) and b) in 2.3.: The voicing process is a case of lenition, and it was argued above that fricatives are more likely to be affected by lenition under coarticulation. Verner's great discovery was that he was able to describe the situation where the fricatives were *not* affected by lenition. When a Proto-Germanic fricative was in initial position or immediately followed the lexical accent, no voicing occurred. This section will outline the phonetic basis for these exceptions.

6.2. The initial position of a word commonly escapes lenition in languages with such processes (Kirchner 2001:9), and there are several factors working together to ensure this for Germanic:

6.3. As shown above in 5.2., voicing lenition of a fricative occurs through coarticulation with a preceding vowel, not a following vowel. In initial position, there would be no preceding vowel or sonorant whose voicing would lag into the fricative. Additionally, the initial consonant of a word is commonly lengthened and strengthened (Fougeron/Keating 1997), and these articulations are antagonistic to lenition, which involves shortening and weakening (3.2., 3.3.). Finally, the initial segment of a word carries a heavy functional load in word recognition, since lexical access is initiated by the listener as soon as linguistic material is being perceived (Kirchner 2004:316, Smith 2005:206ff.). In order to retain a quick and successful lexical access, the initial segment is less likely to undergo changes than other segments (Nooteboom 1981:422).

6.4. The more notable exception to the fricative voicing is in the position immediately after the lexical accent. As an illustration, */maɸá/ will undergo voicing to */maβá/, whereas in */máɸa/, where the sonorant preceding the fricative /ɸ/ carries the lexical accent, no voicing of /ɸ/ takes place.

6.5. An important underlying assumption here is that the Proto-Germanic lexical accent was primarily characterized by a high pitch (cf. e.g. Meillet 1970:37). Now, as shown in 5.2. above, a voiceless fricative is affected in its voicing quality primarily by the *preceding* sonorant. The question is therefore why a high pitched vowel prevents voicing lenition of a following voiceless fricative.

6.6. The answer will follow from the facts noted in the previous sections. As explained in 5.3., both voiceless obstruents and high pitched sonorants share the laryngeal specification of a high longitudinal tension of the vocal folds (Halle/Stevens 1971:204, 208). The distance in the laryngeal articulation between an accented vowel and a following voiceless fricative in Proto-Germanic is therefore small, and consequently less prone to undergo coarticulation (4.7.).[3]

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[3] Some phonological accounts of this exception to fricative voicing in Germanic assume a 'reverse' coarticulatory explanation, in that a proposed phonological feature [stiff vocal folds], used to mark a high pitch on sonorants, spreads to a following voiceless fricative, thus inhibiting voicing (d'Alquen 1988:18, Page 1997:188f., Holsinger 2000:156, Iverson/Salmons 2003:60). This account misses the articulatory fact that voiceless fricatives are inherently produced with 'stiff vocal folds' as a mean to suppress voicing (see 4.6.). The exception to voicing explained in 6.4. is therefore not the result of coarticulation, but rather the result of

## 7. Phonologization of Verner's law

7.1. At the initiation of a coarticulatory process, the coarticulation between two segments is only partial. Even if the articulatory targets in segment /B/ in a segmental string /AB/ can be delayed due to coarticulation with segment /A/, we would expect the targets to be reached eventually. The laryngeal coarticulation of a Proto-Germanic string */maɸá/ would consequently be expected to be realized as *[maβ͡ɸá] with a partially voiced [β͡ɸ] in the initial stages of the voicing lenition process. The eventual phonological outcome /β/ is the result of the following factors:

7.2. In the perception of fricatives, experiments show that listeners determine whether a fricative is voiced or voiceless primarily based on the presence and duration of voicing in the *onset* of the fricative (Stevens et al. 1992:2993ff.). As a result, [β͡ɸ] is likely to be perceived as /β/. In addition, when a phonetic coarticulation becomes phonologized, it is a descriptive fact that the phonetic quality that has been interpreted as intentional becomes clarified and enhanced (Hyman 1976:408, Ohala 1993b:259f.). In sum, it is expected based on both experimental data and descriptive data that a coarticulated [β͡ɸ] in Proto-Germanic will end up as /β/ when phonologized.

7.3. Another question is why the voicing coarticulation was phonologized at all. At this stage of Proto-Germanic, the quality of non-initial fricatives would be predictable from the pitch of the preceding sonorant: Whenever the fricative was preceded by a high pitch, the fricative was voiceless, elsewhere it was partially voiced. Whenever such low-level phonetic implementation of a segment is predictable, listeners generally factor out these properties in their phonological analysis (Ohala 1993b:245). Since the fricative voicing became phonologized through Verner's law, it shows that at some point, this property was no longer factored out. The primary cause for phonologization of phonetic coarticulation is the familiar 'loss of conditioning environment'. Since the conditioning environment for Verner's law in Proto-Germanic was the location of the free mobile accent, it follows that the most probable reason for the phonologization of Verner's law is the Germanic relocation of the accent to the initial syllable.

7.4. Cross-linguistic correlates of stress generally include pitch, duration, and strengthening, meaning that a stressed syllable tends to have a higher pitch, be longer, and have more clearly articulated segments (Fry 1958, de Jong 1995, Sluijter/van Heuven 1996:2475f., Steriade 2007). These articulations are also commonly present in initial syllables, independent of the stress placement (Fougeron/Keating 1997, Ladd 2001:1381, Barnes 2006:188ff., Lehnert-LeHouillier/McDonough 2009). These cues to initiality can therefore be misinterpreted as cues to stress, and thus lead the listener to reanalyze the input as having an initial stress assignment. These facts are clearly paramount in accounting for the disproportionally high amount of languages with initial stress (cf. Hyman 1977:59ff., Gordon 2002:495).

7.5. If we take Proto-Germanic to have been a natural language, it is safe to assume that some, if not all, of these articulations were associated with initial syllables, causing a reanalysis to initial stress. When a Germanic speaker uttered *[máɸa] and *[maβ͡ɸá], the listener would be the stress reanalysis hear *[máɸa] and *[máβ͡ɸa] with a fixed initial stress.

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*lack* of coarticulation. The phonetic explanation outlined in this paper is therefore more in line with the phonological account in Halle 2003:166, where the fricative voicing is explained as a spreading of the feature [–stiff vocal folds] from a low pitched vowel unto a voiceless fricative.

To the listener, there is no longer any conditioning environment for the difference in voicing between the two forms, and is left with little choice but to assume that the distinction in voicing was intended by the speaker. Through the phonologization process (7.2.), the listener will internalize this distinction as a voicing contrast */máɸa/ vs. */máβa/, giving the outcome of Verner's law.

## 8. Typology of Verner's law

8.1. By Verner's law, the pitch in effect determines the voicing quality of a following fricative. It has been pointed out before (Calabrese/Halle 1998:60, Petrova 2004:377) that this contradicts Hyman and Schuh's generalization that 'tone does not affect consonants' (1974:108, Hyman 1975:229).

8.2. There are several languages, though, that behave similarly to Proto-Germanic in that the presence or absence of the lexical accent or a high pitch directly determines the voicing quality of a following obstruent. Languages noted in the literature as exhibiting such behavior are Jingpho (Matisoff 1973:77, Maddieson 1974:18f., 1976:134f.), Sireniki (Hammerich 1955:25),[4] Wuyi (Yip 1995:485), Yabem (Poser 1981, Hansson 2004:319), and to some extent English and German (cf. Ramers 1994:279). Since these languages are both geographically spread and unrelated to each other, it suggests that they exhibit independent developments, thus supporting the naturalness of Verner's law in Germanic.

## 9. Conclusion

This paper has outlined the underlying phonetic basis for the implementation, scope, and phonologization of Verner's law. In summary, I have argued for the following:

- Implementation: Verner's law is a case of lenition through coarticulation.
- Scope: The coarticulation affects voiceless fricatives due to their extreme laryngeal settings and non-contrastiveness in voicing. Fricatives following a high pitched sonorant remain voiceless due to their similar articulation of vocal fold tension.
- Phonologization: The coarticulatory voicing is phonologized as a result of accent retraction, after which the listener cannot attribute the voicing to any other predictable phonetic source.

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[4] I am not able to independently confirm the Sireniki data described by Hammerich. Hammerich does not identify the language beyond its family "Alaska-Eskimoisch", and he cites no source. The cited language is nevertheless surely Sireniki, since Hammerich's base form "*L'toX* ‚Enkel'" matches the Sireniki form /əltəX/ 'grandchild' given in Fortescue et al. (1994:107), and the indicated placement of the accent for the different case forms matches the (penultimate) accent for Sireniki described by Menovschikov 1997:81. Whereas Hammerich analyzes the distribution of intervocalic /X/ and /R/ as conditioned by the accent, Menovschikov 1964:20 claims that /X/ is always voiced to /R/ in intervocalic position. Nikolai Vakhtin (p.c.) supports Menovschikov's claim, but adds that "some people may pronounce the R in a less emphatic manner and it may sound like X". Steven Jacobson (p.c.) adds that "There is quite a bit of interplay between the voiced and voiceless uvular fricative (R and X), in several of these languages, and it's not always easy to hear the difference". It remains unclear to me whether this reported variation between /X/ and /R/ can be intertwined with the accent, as claimed by Hammerich. Sireniki is extinct as of 1997 (Vakhtin 1998:162).

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