Laryngeal Phonetics and Phonology in Germanic

By

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Abstract

Languages differ both in their phonological contrasts and how those contrasts are phonetically implemented. Implementation inevitably introduces variation at different levels, including regional, gender, and inter- and even intra-speaker variation. This dissertation investigates phonetic variation vs. phonological contrast by examining laryngeal phonetics and phonology in three Germanic varieties – Oslo Norwegian, Randstad Dutch, and Bernese Swiss German – that differ in their laryngeal settings. Norwegian is often described as an 'aspirating' language and Dutch as a 'voicing' language, but the Swiss German contrast is based on duration rather than aspiration or voicing. This set of languages covers the range of laryngeal contrasts in Germanic, but only scratches the surface in terms of regional variation; a survey of modern Germanic languages in Chapter 1 reveals that even among 'aspirating' languages, which are analyzed as having the same laryngeal specification in the phonology, a great deal of phonetic variation exists, often between varieties of the same language.

To illustrate historical changes in laryngeal contrasts and to provide context for the modern contrasts, historical background is given for Germanic and each of the languages in this study. For each, experimental phonetic data is presented that bears on obstruent laryngeal contrast; that is, both stops and fricatives (and affricates, for Swiss German) are examined in both simple and complex (i.e. obstruent + sonorant) onsets. I focus on word-initial position, but include some medial environments. The results are then analyzed according to the contrast and enhancement model (Hall 2011), which determines whether a feature is contrastive based on phonological activity but also predicts that redundant (predictable, non-contrastive) features can be used to phonetically enhance the contrastive features. Results show that [spr gl] is phonologically active and therefore contrastive in Oslo Norwegian, and that [voice] is used as a phonetic enhancement; in Bernese Swiss German, obstruents are laryngeally unspecified, but length is phonologically contrastive; in Randstad Dutch, instead of robust voicing, multiple cues are used to mark the contrast. In each case, the separate but related roles of phonetics and phonology play a key role in the analysis of the results.

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction

1.1. Overview

A considerable amount of literature in recent years has been devoted to laryngeal, or what were traditionally called 'voicing', contrasts in Germanic. Germanic languages are now typically divided into 'aspirating' languages (e.g. English and German) and 'voicing' languages (e.g. Dutch and Yiddish). Increasingly, this literature is beginning to show that phonetic implementation of 'aspiration' and 'voicing' varies widely across the Germanic spectrum. It also reveals that in phonetic implementation, there is a good deal of variation in different word positions within the same language, but that the most stable position for the underlying representation to surface appears to be word-initial, or at least the onset of a stressed syllable. Iverson & Salmons add that in English, "the extent of the aspiration which inheres in voiceless stops varies according to the metrical prominence of the syllables they initiate…and according to whether the [spread glottis] feature is independent or shared" (1995:8; citing Kiparsky 1979 and Nespor & Vogel 1986). Thus the degree to which aspiration is phonetically implemented corresponds to metrical prominence; i.e., a fortis stop in the onset of a syllable with primary stress is more strongly aspirated than one with secondary stress, with weak (or no) aspiration in coda position.

In terms of phonology, 'aspirating' languages are reported to exhibit sonorant devoicing and assimilation to voicelessness in clusters, while 'voicing' languages are predicted to lack sonorant devoicing and exhibit voicing assimilation in clusters; this is interpreted as the sharing of a laryngeal feature in consonant clusters (Iverson & Salmons 1995). However, these discussions tend to focus solely on stop consonants, even though there is also a laryngeal contrast in the fricatives in most Germanic languages; the notable exceptions to this are the fair amount of literature on Dutch fricatives (Section 1.3.6; Chapter 4) and Vaux's (1998) discussion of fricative laryngeal features more generally. Furthermore, the issues of sonorant devoicing and assimilation often rely on impressionistic data rather than acoustic analysis, though there has been more acoustic analysis in recent years; subsequent sections of this dissertation review some of these acoustic studies. The relevance of acoustic studies to phonology is that sometimes, the assumed phonological pattern of a language turns out not to match the phonetic data, yet the phonetic data can also support an alternative phonological analysis that in turn is able to account for other phonological processes. For example, as discussed below, acoustic analyses of American English reveal that the 'voiced'/'voiceless' distinction is better stated in terms of a 'voiceless'/'aspirated' distinction, but this is still a phonetic description of the contrast; phonologically, as argued by Iverson & Salmons (1995), the phonetic gesture that produces aspiration reflects an underlying phonological [spr gl] specification. In this way, aspiration, sonorant devoicing, and the spreading of voicelessness in clusters are all accounted for by a [spr gl] specification rather than positing a separate rule to account for surface aspiration from a phonological [-voice] specification.

This dissertation addresses these issues by examining laryngeal phonetics and laryngeal phonology in a set of three Germanic languages, namely Norwegian, Dutch, and Swiss German. I focus on the production of laryngeal contrasts in word-initial, stressed position, for both stops and fricatives (and affricates, in the case of Swiss German), with some additional discussion of assimilation in Norwegian and Dutch and quantity in Swiss German. As in other Germanic languages, Norwegian, Dutch, and Swiss German exhibit a phonological contrast in how the sounds spelled *b* and *p*, for example, are pronounced. This contrast was traditionally in modern linguistics described in terms of voicing; /b/ is ‘voiced’ while /p/ is ‘voiceless’. This is interpreted as a difference in laryngeal activity between /b/ and /p/. However, these three languages manifest the contrast between /b/ and /p/ in different ways, both phonetically and phonologically. Norwegian is described as an ‘aspirating’ language, where /b/ is not actively voiced and /p/ is voiceless and aspirated; phonologically, both sonorant devoicing and assimilation to voicelessness in obstruent clusters occur (e.g. Kristoffersen 2000). Dutch, on the other hand, is described as a ‘voicing’ language, where /b/ is actively voiced and /p/ is voiceless but unaspirated; in contrast to Norwegian, Dutch obstruent clusters are said to exhibit voicing assimilation (e.g. Booij 1995). In Swiss German, however, the contrast is not even laryngeal, but durational; both /b/ and /p/ are voiceless and unaspirated, but /p/ is longer in duration than /b/, and this phonetic durational difference is said to reflect a phonological length contrast that is also a quantity contrast (e.g. Kraehenmann 2003, Seiler 2005b). Thus although these languages share a common ancestor, they all differ from each other in their laryngeal settings.

In this dissertation, I examine some of the historical developments that affected and shaped the obstruent systems of each language, provide experimental phonetic data that bear on the issues outlined above, and present a phonological analysis based on the ‘contrast and enhancement’ model (Hall 2011) that accounts for the differences in phonological specification as well as variation in phonetic realization. Specifically, this dissertation includes acoustic analysis of not only word-initial obstruents, but also word-initial obstruent-sonorant clusters as well as some word-medial assimilation environments. In addition to contributing original acoustic data that expand on previous descriptions of Germanic laryngeal contrasts, I also demonstrate, based on these data, that the 'contrast and enhancement' model, in conjunction with privativity and laryngeal realism, is able to account for some of the more problematic phonological issues in previous accounts. For example, Kristoffersen claims that in Urban East Norwegian, /p, t, k, f/ all induce sonorant devoicing, but /s/ does not, arguing that it is laryngeally unspecified, in part because it lacks a voiced counterpart /z/ (2000:74-87); in Dutch, /b, d/ are said to induce regressive voicing assimilation while /v, z/ do not (Booij 1995, Zonneveld 2007); and Swiss German stops exhibit a length contrast in all word positions, but there is no word-initial length contrast for the fricatives, and length does not appear to be contrastive for the affricates in any position (Willi 1996, Ham 1998, Kraehenmann 2003) – as far as I am aware, it has not been investigated whether the fricatives and affricates (which are all voiceless) bear any laryngeal specification.

The following section lays out the diachronic background that is common to the modern Germanic languages, paying particular attention to phonological contrasts in the obstruent system and some of the changes that affected it. Section 1.3 surveys the synchronic variation in the obstruent systems of the modern Germanic languages, citing key phonetic studies that deal with laryngeal distinctions.

1.2. Diachronic background

Although this dissertation focuses on synchronic analysis, some discussion of the diachronic context can shed some light on the separate development of voicing contrasts in the languages being investigated. I adopt primarily a Tree Model approach to the genetic relationships here, where the divisions are based on one or more groups diverging from each other and/or the main group; this is done mainly for ease of conceptualization, and also because it continues to be widely used in the literature, including most of the sources referred to here. The Wave Model, which is based on independent 'waves' of innovation diffusing from one group to another, is argued to be more accurate, but it is also more complex than is necessary for the present discussion. See François (2014) for an overview of both models as well as an extension of the Wave Model.

The three languages analyzed in this dissertation, Norwegian, Dutch, and Swiss German, all belong to the Germanic (Gmc) branch of the Indo-European (IE) language family. The Germanic languages are further divided into North, West, and East Germanic (NGmc, WGmc, and EGmc). There are no living EGmc languages, but a number of EGmc manuscripts have survived, most notably Wulfila's 4th century translation of the Bible into Gothic (Bennett 1980, Braune 1981). Therefore, all living Gmc languages are either NGmc or WGmc. Norwegian is a NGmc language and underwent subsequent sound changes that did not occur in WGmc. Dutch and Swiss German, though they are both WGmc, show considerable differences in their consonant inventories due to the fact that Swiss German underwent the full extent of the High German Consonant Shift (discussed in chapter 5) while Dutch remained untouched by it. Thus they all exhibit differences in the development of their consonant inventories as well as their laryngeal settings. The following is a brief account of Proto-Indo-European (PIE) phonology and the relevant sound changes that took place between PIE and Proto-Germanic (PGmc). Table 1.1 shows the reconstructed consonant inventory for PIE:

		labial	coronal	palatal	velar	labiovelar	laryngeal
Stops	voiceless	p	t	ḱ	k	k^w	
	voiced	b	d	ǵ	g	g^w	
	voiced asp.	b^h	d^h	$\acute{g}^h$	g^h	g^{wh}	
Fricatives			s				h_1, h_2, h_3
Sonorants	nasal	m	n				
	liquid		l, r				
	glide			j		w	

Table 1.1 PIE consonant inventory. Adapted from Prokosch (1939:38-47), Sihler (1995:135), and Ringe (2006:6-9)

Prior to PGmc, a number of changes took place that altered the consonant inventory; here are a few of the more relevant ones:

1) a. The laryngeal series was either lost completely or became vocalic, depending on the environment (see Ringe 2006:68-81 for details and a few exceptions) and need not concern us in the remaining discussion.

   b. The palatal stops merged with the velar stops, leaving only velars (*k, *g, *g^h) and labiovelars (*k^w, *g^w, *g^{wh}). (See Ringe 2006:88-93 for further details on the development of the velars and labiovelars.)

Since the laryngeals were lost prior to PGmc, the only attested fricative to be inherited by PGmc was *s. Additionally, the PIE voiceless stops were probably plain, unaspirated stops; a series of voiceless aspirated stops has also been posited (p^h, t^h, $\acute{k}^h$, k^h, k^{wh}; but these are attested apparently only in Sanskrit and Greek), and the "glottalic theory"[1] posits a series of ejectives in addition to voiced and voiceless stops with non-contrastive aspiration (see Prokosch 1939:38-39, Hock &

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[1] See Salmons (1993) for an overview and critique of the "glottalic theory".

Joseph 1996:471-474, and Ringe 2006:8). Table 1.1 therefore represents the most widely accepted reconstruction of the PIE consonant inventory. We now turn to the additional sound changes that took place to create the PGmc consonant inventory.

1.2.1. Grimm's Law

The basics of the series of sound changes that came to be known as Grimm's Law are widely known and well documented. I cover them here briefly only to provide some context, followed by a discussion of a few apparent "exceptions". Grimm's Law is a series of systematic sound changes, first formalized by Danish linguist Rasmus Rask, but refined by German linguist Jakob Grimm; the sound changes took place in the following order:

2) a. PIE voiceless stops > PGmc fortis fricatives:

*p, *t, *k, *k^{w} > *f, *þ, *h, *h^{w}

b. PIE voiced stops > PGmc fortis stops:

*b, *d, *g, *g^{w} > *p, *t, *k, *k^{w}

c. PIE voiced aspirates > PGmc lenis obstruents:

*b^{h}, *d^{h}, *g^{h}, *g^{wh} > *b, *d, *g, *b/*g^{w} / *ƀ, *ð, *ǥ, (*w/*ǥ^{w})[2, 3]

A few remarks are in order here. First of all, it has long been common in Germanic linguistics to use the terms *fortis* for 'voiceless' and *lenis* for 'voiced'; I adopt those terms here for the Germanic reflexes of PIE obstruents, but this is done in the interest of presentational expedience as a means of representing laryngeal contrasts, not due to any perceived difference in 'force of

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[2] A note on the orthography I adopt here: In Germanic historical linguistics, it is common to use *f to denote a voiceless labial fricative (whether bilabial [ɸ] or labiodental [f]); *þ to denote a voiceless interdental fricative (instead of IPA [θ]); *h to denote a voiceless velar [x], uvular [χ], or laryngeal [h] fricative; *ƀ to denote a voiced labial fricative (which later became labiodental [v] in many cases); *ð to denote a voiced interdental fricative; and *ǥ to denote a voiced velar fricative (instead of IPA [ɣ]).

[3] See Ringe (2006:105-112) for more on the development of the labiovelars.

articulation'[4] or any other specific phonetic properties (e.g. Lisker & Abramson 1964, Kohler 1984; see also Braun 1988 for an overview).[5] However, parallel to Docherty's (1992) adoption of the terms VOICED and VOICELESS, in all caps, to refer to phonological categories, I use the terms LENIS and FORTIS in all caps specifically when referring to the modern Germanic reflexes of the PGmc categories (I continue to use lowercase 'lenis' and 'fortis' for any historical forms); this aids in comparing the phonetic and phonological differences between languages while retaining the insight that they developed from the same source. Second, it is assumed that the PIE voiceless stops first became aspirated before becoming fricatives (Prokosch 1939:59, Iverson & Salmons 2003a:53). Additionally, it is widely believed that the PGmc fortis velar fricatives were phonetically [h], [h^{w}] in word-initial position fairly early in PGmc and were velar [x] or uvular [χ] in other environments. Furthermore, the resulting PGmc voiced obstruents in stage 3 were either stops or fricatives depending on the environment. According to Ringe (2006:100), the pattern of allophony is as follows:

3) a. They were all stops after homorganic nasals: *-mb, *-nd, *-ŋg, *-ŋg^{w}

b. *d was a stop after *l and *z (also after *r in Gothic): *-ld, *-zd

c. *b and *d were stops word-initially[6]

d. Elsewhere, they were fricatives: *ƀ, *ð, *ǥ

Iverson & Salmons (2003a:58-59) argue that the fricative allophones of the PGmc lenis stops were the result of a Spanish-like 'passive spirantization', suggesting that the PGmc lenis stops were underspecified for [continuant]; we return to this topic below.

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[4] See Rodgers (2014) for a related discussion of laryngeal contrasts with a focus on energy measurements.

[5] Willi's (1996:196) summary of Kohler's theory (1984) is that the various correlates of the LENIS/FORTIS contrast don't have to be there all at once, but language-specific realizations will favor one or more over one or more of the others.

[6] Though there are a few runic inscriptions with word-initial spirantized *ƀ and *ð, e.g. Prokosch 1939:75.

We now turn to a discussion of several interesting "exceptions" to Grimm's Law, all of which involve obstruent-obstruent clusters in which the second segment is a PIE voiceless obstruent. In the first type, the first segment is *s (all examples in 4, 5, and 6 below are from Prokosch 1939, Watkins 2000, and Ringe 2006):

4) PIE *spō-ti- > PGmc *spōdiz 'speed' *sp > *sp

PIE *stoi-no- > PGmc *stainaz 'stone' *st > *st

PIE *skū-mo- > PGmc *skūmaz 'scum' *sk > *sk

This type of "exception" is well known in Germanic linguistics. In these examples, PIE *p, *t, *k did not follow the first stage of Grimm's Law and become PGmc *f, *þ, *h. The second type of "exception" is also well known in Germanic linguistics:

5) PIE *k$h_2$ptós > PGmc *haftaz 'captive'[7] *pt > *ft

PIE *oḱtów > PGmc *ahtōu 'eight' *kt > *ht

PIE *swéḱs (> *séḱs) > PGmc *sehs 'six' *ks > *hs

A generalization can be made based on these first two types of "exceptions": For Grimm's Law stage 1, PIE voiceless stops became PGmc fortis fricatives unless they were immediately preceded by a PIE voiceless obstruent. I share the view of Iverson & Salmons (1995:14-17), who argue that clusters of these types share "a single laryngeal gesture…, with peak glottal width occurring toward the end of the first obstruent, narrowing to the point of closure during the course of the second obstruent" (1995:16). In other words, the second member of these clusters was unaspirated, which is a prerequisite for fricativization in Grimm's Law stage 1. Lacking aspiration, the stops in clusters of the type *sk remained unshifted, with most of the glottal

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[7] Note that the translation for PGmc *haftaz, 'captive', is a borrowing from Latin *captus* that comes from the same IE root, and the word-medial -*pt*- is unchanged in Latin.

spreading gesture occurring during production of the first member of the cluster *s. In clusters of the type *kt, only the first stop shifted (> PGmc *ht) because the peak of the glottal spreading gesture occurred during production of the first member *k, leaving *t unaspirated and unshifted. (Laryngeal gestures are discussed in detail in Chapter 2.)

The third type of “exception” is similar to the second (together, they are commonly referred to as examples of *Primärberührung* or ‘primary contact’; see e.g. Paul 2007:125), but it involves both PIE voiced and voiced aspirated stops:

6) PIE *g^{h}eb^{h}-ti- > PGmc *giftiz ‘gift’ *b^{h}t > *ft
PIE *wob^{h}seh$_{2}$ > PGmc *wafsō ‘wasp’ *b^{h}s > *fs
PIE *h$_{3}$reǵtós > PGmc *rehtaz ‘straight’ *ǵt > *ht
PIE *h$_{2}$eǵ-s- > PGmc *ahsō ‘axle’ *ǵs > *hs
PIE *weg^{h}-ti- > PGmc *wihtiz ‘weight’ *g^{h}t > *ht
PIE *leg^{wh}-t- > PGmc *līhtaz ‘lightweight’ *g^{wh}t > *ht
(see Ringe 2006:112-115 for more examples and further discussion)

In these examples, both PIE voiced and voiced aspirated stops became PGmc fortis fricatives before *t and *s. The fact that they became fricatives, as opposed to stops, in all of the Gmc daughter languages suggests that they were already voiceless stops before Grimm’s Law took place; this would explain how they underwent the same sound change, in the same position, as the PIE voiceless stops. As Ringe (2006:115) states, “The simplest scenario is that all stops were devoiced before voiceless obstruents in pre-Germanic…before Grimm’s Law occurred and thus underwent Grimm’s Law…”. Following Iverson & Salmons (1995), we can capture all three types of “exceptions” to Grimm’s Law by positing a shared glottal spreading gesture; but in the third type, we can argue for feature spreading rather than feature sharing, suggesting that the feature [spr gl] was phonologically active at a fairly early stage in PGmc.

1.2.2. Spirantization

As mentioned above, once the PIE voiced aspirated stops became lenis stops in PGmc, they acquired spirantized allophones in certain environments (likely because they were underspecified for continuancy, as mentioned above, and as argued in Iverson & Salmons 2003a:58-59). The spirantization of lenis stops occurred across PGmc, but it was mostly limited to non-initial position or when immediately preceded by *l*, *m*, *n* (Haugen 1982:61). The following examples of intervocalic and final *b illustrate both spirantization and widespread final devoicing in Germanic:[8]

	PGmc	Gothic	ON	OE	OHG	gloss
infinitive	*geban	giban [v]	gefa [v]	gifan [v]	geban [b]	‘to give’
3sg. past indic.	*gab	gaf [f]	gaf [f]	geaf [f]	gab [p]	‘gave’

The Gothic example is particularly illustrative since it exhibits a spelling with *b* and the devoiced alternation with *f*, suggesting that the medial *b* was almost certainly spirantized. The difference in OHG is due to the fact that spirantization in Upper German dialects was later reversed (Braune 2004, Paul 2007). As will be discussed below as well as in subsequent chapters, spirantization

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[8] Throughout this chapter, historical Gmc forms are from Bandle et al. (2002, 2005), Barnes (2008), Bennett (1980), Braune (1981, 2004), Bremmer (2009), Faulkes (2007), Faulkes & Barnes (2007), Gordon (1957), Haugen (1976, 1982), Meineke & Schwerdt (2001), Noreen (1970), Paul (2007), Penzl (1971), Prokosch (1939), Rauch (1992), Ringe (2006), Robinson (1992), Sihler (1995), Sonderegger (2003), Watkins (2000), and Wells (1990). These sources show some differences in interpretation to a greater or lesser extent, but the purpose here is simply to give a general overview.

has persisted into many modern Germanic languages, in some cases leading to the development of (or merger with) LENIS fricative phonemes in several daughter languages.

1.2.3. Verner's Law and the subsequent accent shift

Verner's Law (named after the Danish linguist Karl Verner who made the discovery) explains the alternation of PGmc fortis fricatives (including inherited *s from PIE) to lenis fricatives when the following conditions were met:

7) a. they were not word-initial,
   b. they were not adjacent to a fortis sound, and
   c. they were not immediately preceded by a stressed syllable nucleus in PIE (see Ringe 2006:102-105 for further details, but also Iverson & Salmons 2003a)

Verner's Law preceded the accent shift to the root syllable that occurred across PGmc (in PIE, accent was lexical), but certainly must have followed Grimm's Law since it only operated on the fortis fricatives that resulted from Grimm's Law, as the development of the word 'father' shows:

8) Grimm's Law: *ph$_2$tér > *faþér   *p > *f, *t > *þ (cf. Latin *pater*)
   Verner's Law: *faþér > *faðér   *f (no change), *þ > *ð
   Accent Shift: *faðér > *fáðer

After Grimm's and Verner's Laws had run their course, the consonant inventory for PGmc became as shown in Table 1.2:

		labial	dental	coronal	palatal	velar	labiovelar
Stops	fortis	p		t		k	k^w
	lenis	b		d		g	g^w
Fricatives	fortis	f	þ	s		h	h^w
	lenis	v/ƀ	ð	z		ǥ	$ǥ^w$
Sonorants	nasal	m		n			
	liquid			l, r			
	glide				j		w

Table 1.2 PGmc consonant inventory, based on Ringe (2006:214)

When the conditioning environment for Verner's Law was lost due to the accent shift to the root syllable, the lenis allophones of the fortis fricatives became phonemic, and these eventually merged with the spirantized lenis stops. Thus Table 1.2 represents the NWGmc consonant phoneme inventory that was inherited by the daughter languages;[9] compared to the inventory posited for PIE in Table 1.1, with a three-way laryngeal contrast (voiceless, voiced, voiced aspirated), here we see a simple two-way laryngeal contrast.

Since these changes targeted and altered laryngeal contrasts in early Germanic, some discussion of laryngeal features is in order here. Iverson & Salmons (2003a:60) argue that the fortis stops were underlyingly unspecified for laryngeal features, but were phonetically enhanced with [spr gl] in the initial stages, before the PIE voiced and voiced aspirated series shifted to PGmc fortis and lenis, respectively. Then the enhanced [spr gl] series became fricativized through the

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[9] It is unclear whether EGmc participated in Verner's Law; see Ringe 2006:213-214 for discussion of a NWGmc subgrouping.

first stage of Grimm’s Law, and later contrasted with the lenis fricatives that developed from the passively spirantized (and underlyingly specified for [voice]) lenis stops as well as the passively voiced fortis fricatives due to Verner’s Law and the subsequent accent shift. This introduced [spr gl] into the system as a phonologically contrastive feature, not just a phonetic enhancement:

PIE	*p, *t, *k, *k^{w} [ ]	
Early PGmc	*p^{h}, *t^{h}, *k^{h}, *k^{wh} [ ]	
Grimm (1)	*f, *þ, *h, *h^{w} (*s) [ ]	
Verner’s Law	*f, *þ, *h, *h^{w} (*s) ~ *ƀ, *ð, *ǥ, *ǥ^{w} (*z) [ ] [ ]	
Accent Shift	*f, *þ, *h, *h^{w} (*s) [spr gl]	*ƀ, *ð, *ǥ, *ǥ^{w} (*z) [ ]

Table 1.3 The development of contrastive [spr gl] in Gmc, per Iverson & Salmons (2003a)

Meanwhile, the PIE voiced aspirated series became deaspirated, and the PIE voiced series became devoiced and subsequently enhanced with [spr gl] to contrast it with the now deaspirated voiced series. Additionally, Iverson & Salmons (2003a:59-60) argue that Verner’s Law isn’t so much that fricatives became voiced/lenis when they weren’t immediately preceded by a stressed vowel, but that a preceding stressed vowel prevented passive voicing by virtue of the [stiff vocal folds] specification for the high pitch accent on that vowel. The fricatives, for a very long time, exhibited no laryngeal contrast word-initially.

1.2.4. Loss of *z in NWGmc: Rhotacization

Rhotacization is the process by which the lenis allophone of PGmc *s, [z], became /r/; this change is limited to NWGmc as it remained [z] in EGmc.[10] For a time, it remained a separate phoneme from /r/, having its own symbol in the runic alphabet (usually transcribed as R), and showing up as *z* or *s* in some ON texts. It also sometimes caused palatal mutation, so it may have been a lenis palatal fricative [ʒ] or something close to it. Eventually, however, it merged with /r/ in NWGmc:

Gothic	ON	OE	OHG	gloss
maiza	meire	māra	mēro	‘more’

In WGmc, *s eventually acquired new LENIS allophones (e.g. German *sagen* [z-] ‘to say’, *Nase* [-z-] ‘nose’, *Nässe* [-s-] ‘wetness’;[11] cf. English *zoo* [z-], *sue* [s-]; *lose* [-z], *loose* [-s]), but it remains FORTIS in all positions in all NGmc languages (e.g. Norwegian *si* [s-] ‘to say’, *nese* [-s-] ‘nose’).

1.2.5. PGmc to NGmc

NGmc is typically split into West NGmc (WNGmc) and East NGmc (ENGmc), but they probably were not differentiated until about 800 AD (e.g. Faarlund 1994:38). WNGmc includes Icelandic, Faroese, most Norwegian dialects with the exception of the area in and around Oslo, and a few dialects of Swedish. ENGmc includes most Swedish dialects and Danish, as well as the dialects of the Oslo area. (See e.g. Haugen 1982:9-12 for discussion.) Additionally, ON as it

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[10] Robert Howell (p.c.) notes that there is some rhotacism in EGmc, such as PGmc **uz-reisan* > Gothic *urreisan* ‘arise’, but adds that it must post-date breaking and is therefore unrelated to rhotacism in NWGmc.

[11] Wiese (1996:12, 176-177) notes that in German, word-initial /s/ is restricted to loanwords, but even then it is often adapted to the native system, such that *Sex* ‘id.’ can vary between [s-] and [z-].

appears in textbooks today is a normalized form of West Norse (WN), which differs significantly from East Norse (EN). WN texts were written mainly in Iceland from approximately 1150-1350, with a few texts written in Norway, but Iceland was settled by southwestern Norwegians and the languages remained all but identical for some time (Barnes 2008:1-2).

The division between WNGmc and ENGmc is, of course, more of a continuum, but it seems that the transitional area runs through modern Norway. Norway has two written standards: *Bokmål* (lit. 'book speech'), which is based primarily on the dialect of Oslo; and *Nynorsk* (lit. 'new Norwegian'), which is based mainly on the dialects of western Norway (e.g. Kristoffersen 2000:2-6). For our purposes in this section, Bokmål forms will be used to represent ENGmc features of Norwegian, and Nynorsk forms will be used to represent WNGmc features of Norwegian. Many of the characteristic differences between WNGmc and ENGmc have to do with the development of vowels and will not be covered here (see Haugen 1982), but a few of the relevant consonantal differences will be discussed below. (Much of the information in this section comes from Haugen 1982).

The PGmc fricatives *f, *þ, *h were retained word-initially in NGmc. PGmc *f and *þ were also retained word-finally and when adjacent to fortis stops, but they became lenis intervocalically or when adjacent to phonetically voiced segments (Haugen 1982:60):

9) PGmc **wulfaz* > ON *ulfr* [-v-] > Nor. *ulv* 'wolf'[12]

Additionally, PGmc *þ was assimilated to a preceding *l or *n, or was lost (with compensatory lengthening) before *l (ibid.):

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[12] Note that word-final *f has become voiced /v/-/ʋ/ in modern Norwegian, as well as in Swedish and Danish.

10) PGmc **gulþa* > ON *gull* ‘gold’ (assimilation)

PGmc **nēþlō* > ON *nál* ‘needle’ (loss)

PGmc *h was retained as [h] word-initially in all of the Gmc daughter languages, not just NGmc. In NGmc, however, it was also retained word-initially before sonorants but has since been lost in that environment except in modern Icelandic; otherwise it either a) was lost in non-initial position, b) assimilated to a following *t, or c) became a stop before *s (Haugen 1982:60, 63):

11) PGmc **hlahjan* > ON *hlæja* ‘to laugh’ (loss (and initial retention); cf. German *lachen*)

PGmc **ahtō* > ON *átta* ‘eight’ (assimilation; cf. German *acht*)

PGmc **lahsaz* > ON *lax* [ks] ‘salmon’ (stop before /s/; cf. German *Lachs*)

The PGmc stops *p, *t, *k were retained in all positions in NGmc. Additional developments, such as retroflexion, palatalization, and lenition, have altered these stops in the modern languages. For example, lenition in modern Danish and a few dialects of Norwegian and Swedish has caused singleton /p, t, k/ to merge with /b, d, g/ in non-initial position and when not adjacent to a FORTIS obstruent. In Danish, these segments have subsequently undergone further lenition to approximants (Haugen 1982:80; Basbøll 2005):

PGmc	ON	Icelandic	Norwegian	Swedish	Danish	gloss
*dagaz	dagr	dagur [-ɣ-]	dag [-g]	dag [-g]	dag [-j]	‘day’
*sakō	sǫk	sök [-k]	sak [-k]	sak [-k]	sag [-j]	‘case, cause’

Widespread gemination is also a salient feature of NGmc. In many cases, singleton stops become geminates by assimilating a preceding nasal consonant (this is more prevalent in WNGmc than ENGmc; Haugen 1982:61-62):

12) PGmc *_drinkan_ > ON _drikka_ ‘to drink’

Additionally, *g and *k became geminates before *i/j or *u/w (Haugen 1982:58-59):

13) PGmc *_lagjan_ > ON _liggja_ ‘to lay’

PGmc *_rek_^{w}_az_ > ON _røkkr_ ‘darkness’

The PGmc stops *b, *d, *g were spirantized in non-initial position unless they were immediately preceded by _l_, _m_, or _n_, (as mentioned previously for PGmc); geminate stops also did not become spirantized. Additionally, the spirantized stops were devoiced when adjacent to a fortis obstruent or in word-final position (Haugen 1982:61). Eventually, the spirantized allophones of the lenis stops merged with the lenis allophones of the fortis fricatives, as described above.

Finally, *w became a lenis fricative (or approximant /ʋ/) in all of the NGmc languages, merging with both spirantized *b →*ƀ > _v_ and lenited *f →*ƀ > _v_ (Haugen 1982:63-64). PGmc *h^{w} essentially followed the same pattern in non-initial position as *h above, but it has been retained as [x^{w}] word-initially in a dialect of Icelandic (e.g. Árnason 2011:6); otherwise, it has become [kf-] in WNGmc and [v-] in ENGmc (Haugen 1982:66):

14) PGmc *_h_^{w}_at_ > ON _hvat_ ‘what’

WNGmc: Icelandic _hvað_ [kf-] (or [x^{w}-])
Nynorsk _kva_ [kf-]
ENGmc: Bokmål _hva_ [v-]
Swedish _vad_ [v-]
Danish _hvad_ [v-]

Finally, geminate glides *jj, *ww become ‘sharpened’ to -_gg(j)_-, -_gg(w)_- (Haugen 1982:58-59):

15) PGmc **ajja* > ON *egg* ‘egg’

PGmc **treuwaz* > ON *tryggr* ‘true, trusty’

The results of these changes were as follows:

16) *p* contrasted with *b* word-initially and after *m*

t contrasted with *d* word-initially and after *n* and *l*

k contrasted with *g* in all positions (though *g* retained a spirant allophone)

f contrasted with *v* (< PGmc *w) word-initially only

þ did not contrast with *ð* in any position

h did not contrast with *g* in any position

lenis and fortis geminates contrasted medially and finally

Although lenis and fortis geminate stops contrasted in non-initial position, the voicing contrast for singleton stops was all but limited to word-initial position. The situation has changed somewhat in the modern languages:

17) a. *þ* developed a word-initial lenis allophone *ð* (later *d* throughout NGmc except Icelandic) in weakly stressed words, and thus has some word-initial contrast in ON and modern Icelandic (Haugen 1982:66, 69-70)

b. with the exception of Icelandic, *þ*, *ð* have become alveolar stops *t*, *d* (though Danish *d* is a fricative or approximant in non-initial position) (Haugen 1982:66, 80)

c. word-final devoicing has been lost in Norwegian, Swedish, and Danish, meaning that word-final voicing contrasts exist in these languages

There are a number of other changes that have taken place in the various NGmc languages and dialects; subsequent developments in Norwegian with be discussed in chapter 3.

1.2.6. PGmc to WGmc

In contrast to NGmc, which is fairly homogeneous in its early stages and seems to have developed from a single common ancestor, there is no consensus that the group of Germanic dialects that are traditionally labeled “West Germanic” arose from a common WGmc ancestor (e.g. Henriksen & van der Auwera 1994:9). In any case, they are not as homogeneous as NGmc.

The PGmc fortis fricatives *f, *þ, *h, *s had various outcomes in WGmc. WGmc *f and *þ had essentially the same voicing alternations as in NGmc (lenis between phonetically voiced segments, fortis elsewhere), though unlike NGmc, the sibilant *s also had similar voicing alternations in WGmc. Furthermore, *f, *þ, and *s all developed lenis allophones in word-initial position in many WGmc dialects (the so-called *Spirantenschwächung* or ‘spirant lenition’, e.g. Braune 2004, Paul 2007); they were most consistently realized as fortis in word-final position, adjacent to a fortis obstruent, or as geminates. Additionally, *þ became *ð and subsequently *d* in all positions throughout WGmc, spreading south to north starting in the 8th century (Braune 2004:162-167).

However, *f and *s did not complete the shift to an occlusive as *þ did (> *ð > d). For *f, lenition was often, but not systematically, reflected in the orthography as *v*. This lenition process was later reversed in the medieval period in German, and although the orthography has not changed, *v* is now phonetically identical to *f* [f] in standard German; Dutch seems to be following suit (more on this below). The lenition of *s, on the other hand, is reflected only recently in modern Dutch orthography as *z*; German retained orthographic *s*, but it is still LENIS when immediately followed by a vowel.[13] Finally, PGmc *h was retained longer and in more positions in all WGmc dialects than it was in NGmc, with both [h] and [x] (or [χ]) allophones, but with various subsequent developments in the modern WGmc languages. The oldest WGmc written sources still show word-initial *hl*-, *hr*-, *hn*-, *hw*- (Braune 2004:147-152).

PGmc *p, *t, *k remained unchanged throughout WGmc, at least in the early stages (the High German Consonant Shift is discussed in Chapter 5).

PGmc lenis stops *b, *d, *g lost their spirantized allophones to varying degrees. According to Prokosch (1939:76-78), PGmc *ð became *d* in all positions and in all WGmc dialects,[14] PGmc *ƀ remained a spirant medially and finally in the northern WGmc dialects (English, Frisian, Saxon, Low and Middle Franconian) but became *b* in the rest of WGmc, and PGmc *ǥ remained a spirant in all positions (except after nasals or as a geminate) in more or less the same geographical distribution as *ƀ, but varied between being realized as a palatal glide, velar fricative, or velar stop depending on the dialect and the phonological environment (also Braune 2004:80-81, 87-89.)

PGmc *w was retained before vowels throughout WGmc, before sonorants *wl, *wr to varying degrees in the northern WGmc dialects, but was lost early before sonorants in southern WGmc

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[13] According to König (2015:245), /s/ is realized as phonetically voiced in word-initial position only from around Köln northward; even though it is LENIS word-initially in the southern dialects, it is still apparently phonetically voiceless.

[14] Robert Howell (p.c.) points out that intervocalic *ð was lost in western Dutch (*weer* 'again'; cf. modern German *wieder* 'again'), suggesting that *ð had been retained as a fricative and then lost.

dialects (*wl- > l, *wr- > r) (Braune 2004:108). Eventually, *w became an approximant [ʋ] or a fricative [v] throughout continental WGmc.

Gemination was also widespread in WGmc, but it occurred in more environments than it did in NGmc, affecting all syllable-final consonants except when immediately followed by *j, *l, *r, or *w. WGmc gemination was most widespread before *j, more restricted before *l and *r, and only *k was geminated before *w (see e.g. Prokosch 1939:87-88; Braune 2004:98-100):

18) PGmc **bidjan* > OS *biddian* 'to ask for' (before *j)
PGmc **apla*- > OE *æppel* 'apple' (before *l)
PGmc **bitraz* > OS, OHG *bittar* 'bitter' (before *r)
PGmc **nakwadaz* > OHG *nackot* 'naked' (before *w)

In summary, although *p, *t, *k are fairly stable in early WGmc, it is difficult to succinctly describe the distribution of the voicing of *f, *þ, *s and the spirantization of *b, *d, *g in WGmc. It is beyond the scope of this dissertation to describe the outcomes of the PGmc obstruents in complete detail in all of the WGmc dialects; there is already a large body of literature that covers that topic (e.g. Prokosch 1939, Braune 2004, Ringe 2006, Paul 2007, and references therein), and the goal here is simply to provide some context for the temporal and regional variations in the voicing alternations in WGmc. It is sufficient to say that there is a trend toward increasing voicelessness and occlusion from north to south. A subsequent change that had a major effect on the obstruents in certain WGmc dialects, the High German Consonant Shift, will be discussed in Chapter 5.

1.3. Synchronic Background

It is clear at this point that a laryngeal distinction has always existed in Germanic, but it is also clear that obstruent contrasts have varied over time and across Germanic dialects and daughter languages. This section explores this variation in the modern Germanic languages. While many studies note the exceptional behavior of Dutch and (less often) Swiss German within Germanic, they tend to lump together NGmc with English and German as 'aspirating' languages. In terms of surface phonetic variation, however, the situation is far more complex. Several things are worth noting here. One is that the phonological laryngeal contrast is most fully realized word-initially, or in the onset of a stressed syllable; in other positions within the word, processes such as lenition, assimilation, and neutralization can obscure the distinction. Another is that in word-initial, stressed position, the phonetic realization of /b, d, g/ varies widely across the Germanic 'aspirating' languages, from fully voiceless (in Icelandic), to partially voiced (in many languages or varieties), to fully voiced (in Central Standard Swedish and other varieties; see below), while /p, t, k/ are consistently aspirated in this position in these languages. Additionally, there are certain word positions where the laryngeal contrast is neutralized, such as word-medially in Icelandic or word-finally in German and Dutch. The following is a brief summary of some of the more relevant aspects of aspiration and voicing contrasts in Germanic.

1.3.1. Icelandic and Faroese

At the far end of the 'aspirating' spectrum is Icelandic. As Thráinsson (1978, 1994), Ringen (1999), Hansson (2003), Árnason (2011), and others have reported, the distinction in Icelandic stop consonants can more accurately be represented as voiceless unaspirated [p] vs. voiceless aspirated [p^h]:

19) *bar* [pɑːr̥] 'bar' *par* [pʰɑːr̥] ‘pair’

In addition to postaspiration, preaspiration can also occur with geminate FORTIS stops as well as other clusters with FORTIS stops:

20)	*bagga* [pɑkːɑ]	‘bundle-ACC’
	bakka [pɑhkɑ]	‘bank-ACC’
	pakka [pʰɑhkɑ]	‘to pack’
	batna [pɑhtnɑ]	‘to recover, get better’

Furthermore, the contrast is neutralized in postvocalic onset position in the southern dialect of Icelandic, but not in the northern one:

21)	Southern Icelandic:	Northern Icelandic:		
	[tʰɑːpɑ]	[tʰɑːpʰɑ]	*tapa*	‘to lose’
	[pʰɑːtɑ]	[pʰɑːtʰɑ]	*pata*	‘to gesticulate’

Icelandic also exhibits a voicing distinction in the sonorants:[15]

22)	Voiced:	Voiceless:
	jól [joul] ‘Christmas’	*hjól* [çoul] ‘bicycle’
	lið [liːθ] ‘team’	hlið [l̥iːθ] ‘side’
	niður [niðʏr̥] ‘down’	*hnífur* [n̥iːvʏr̥] ‘knife’
	reyna [reina] ‘to try’	*hreyfa* [r̥eiva] ‘to exercise’
	And word-internally before FORTIS stops:	
	lambi [lampi] ‘lamb-DAT’	*lampi* [lam̥pi] ‘lamp’

Hansson (2003) and Árnason (2011) report a similar system in Faroese, with postaspiration, preaspiration, and northern and southern dialects exhibiting similar behavior to northern and

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[15] According to Bombien (2006), ‘voiceless’ sonorants in Icelandic are not always phonetically voiceless, and other phonetic cues seem to be contributing to the distinction.

southern Icelandic; voiceless sonorants occur in Faroese word-internally before FORTIS stops, but not word-initially as they do in Icelandic.

1.3.2. Norwegian

For Norwegian, Kristoffersen (2000:22) states that in Urban East Norwegian, the LENIS stops are voiceless or only partially voiced word-initially and voiced postvocalically, and the FORTIS stops are voiceless and aspirated word-initially and simply voiceless postvocalically. Halvorsen (1998) cites several impressionistic studies of Norwegian stops (Oftedal 1947, Kloster-Jensen 1956, Borgstrøm 1958, Sivertsen 1967, and Haslev 1985), but states that "no investigation of Norwegian VOT has been done to date" (1998:29). In her study, she describes the results for both production and perception experiments for speakers of the Bergen, Trøndelag, and Eastern Norwegian dialects.[16] She reports that while /p, t, k/ regularly have on average approximately 60-65 ms of aspiration, /b, d, g/ occur with voicing lead approximately twice as often as they do with voicing lag, across all three dialects, but that the degree of lead or lag is highly variable, even within the same dialect. In a study of intervocalic stops in the Trøndelag dialect of Norwegian, van Dommelen & Ringen (2007) report that intervocalic FORTIS stops are characterized by some preaspiration, a voiceless closure, and an aspirated release while intervocalic LENIS stops are typically fully voiced. Ringen & van Dommelen (2013) provide additional acoustic evidence for Trøndelag Norwegian that LENIS stops are phonetically voiced in all word positions, including word-initially, and that FORTIS stops are preaspirated word-medially and word-finally, in addition to the expected aspiration of word-initial FORTIS stops. Helgason (2002:60-73) also cites several authors who mention preaspiration in certain

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[16] While Bergen is a city in Norway, Trøndelag and Eastern Norway are larger geographical areas; it is unclear exactly where within these areas the Trøndelag and Eastern Norwegian speakers in Halvorsen's study come from.

Norwegian dialects: Jæren on the southwesternmost tip of Norway (Oftedal 1947, 1972; Wolter 1966), Northern Gudbrandsdalen in eastern Norway (Hesselman 1905, Ross 1907, Storm 1908), Trøndelag in central Norway (Moxness 1997), and the island of Senja in northern Norway (Iversen 1913). Finally, it is well-known that on the southern tip of Norway, as well as in isolated pockets in southern Trøndelag and Nordland provinces, that postvocalic singleton /p, t, k/ are realized as LENIS [b, d, g]: *tape* 'to lose' /tɑpə/→[tʰɑːbə], *kake* 'cake' /kɑkə/→[kʰɑːgə] (see e.g. Sandøy 1992:79, 186 and 1996:152-154; Papazian & Helleland 2005:55, 71; Hanssen 2010:72-73).

1.3.3. Swedish

While there is consensus that Swedish /p, t, k/ are consistently aspirated, several recent studies have shown that in Central Standard Swedish, /b, d, g/ are fully voiced in all positions (Ringen & Helgason 2004; Helgason & Ringen 2007, 2008; Beckman et al. 2011). However, Helgason & Ringen (2008) note in their experimental data that in utterance-initial position, the difference in degree of prevoicing of /b, d, g/ was statistically significant for different speakers and across gender (2008:611), but the difference in the degree of aspiration of /p, t, k/ was not statistically significant for either speaker or gender (2008:614). They also note that in all stop clusters that contain /p, t, k/, assimilation is always to voicelessness (2008:618-619). Keating et al. (1983), however, found no closure voicing and short-lag VOT for word-initial /b, d, g/, and long-lag VOT for word-initial /p, t, k/ for six speakers of Stockholm Swedish. Additionally, Helgason (2002) provides experimental data showing that Central Standard Swedish, Gräsö Swedish, and Western Åland Swedish all exhibit preaspiration of /p, t, k/ in non-initial position. (See also Riad 2014 for further references and analysis.)

1.3.4. Danish

As noted above, widespread lenition of non-initial NGmc *p, *t, *k in Danish has led to a situation where the LENIS/FORTIS distinction is only seen word-initially. However, in spite of this propensity for lenition in Danish, Haugen (1982: 81) says that "[v]oice has ceased to play a significant role in the stop system of Da[nish]…. Voiced stops have been unvoiced, and the distinction voiced-voiceless is maintained only initially, where the old voiceless stops are strongly aspirated…". Additionally, Halvorsen (1998:29-30) cites experimental phonetic studies by Christensen (1984) and Fischer-Jørgensen (1968, 1980) who show that Danish /p/ and /k/ are voiceless aspirated and /b/ and /g/ are voiceless unaspirated, reporting long and short lag VOT values, respectively (the alveolars /t, d/ were apparently left out of these studies because Danish /t/ is affricated [t^s]). Basbøll (2005:60-61, 76) confirms this, stating that all Danish stops are voiceless, with a distinction in aspiration only. He also states (146-148) that the relevant feature is [spr gl] for both stops and fricatives, and that /p, t, k, f, s, ç/ form a natural class as [spr gl] obstruents, part of the supporting evidence being sonorant devoicing after those obstruents. As phonetic evidence, he cites a study by Frøkjær-Jensen et al. (1971) who note that the glottis is open during production of FORTIS stops and fricatives in Danish.

Hutters (1985) provides a detailed phonetic analysis of Danish stops using electromyography, photo-electric glottography, and fiberoptic stills. Her study shows that /p, t, k/ are produced with an active glottis-opening gesture and a large glottal aperture at the time of release, resulting in aspiration, while /b, d, g/ are produced with a much smaller glottal gesture that is nearly completed at the time of release, resulting in a short-lag VOT and no aspiration. Thus Danish seems to behave more like Icelandic and Faroese in this respect, with the distinction between /p, t, k/ and /b, d, g/ being purely based on aspiration for /p, t, k/ and a complete lack of voicing for /b, d, g/, at least in the onset of a stressed syllable.

However, Danish differentiates itself significantly from Icelandic and Faroese, and the rest of NGmc for that matter, by neutralization of the distinction in coda position or intervocalically, as well as widespread lenition of stops to fricatives and approximants. The following example, comparing Norwegian (representing the rest of NGmc) and Danish, illustrates both neutralization and lenition:

23)	Norwegian	Danish	gloss
	dag [dɑːg]	*dag* [dæːɪ]	‘day’
	bake [bɑːkə]	*bage* [bæːɪ]	‘to bake’
BUT:	*bakte* [bɑktə]	*bagte* [bɑktə]/[bɑg̊tə]	‘baked’

Note that the *k*-*g* distinction is retained in Norwegian but merged to *g* in Danish and subsequently underwent significant lenition, but that Danish *bagte* reflects an earlier *bakte* which was retained in pronunciation because it was adjacent to voiceless *t*. According to Haugen (1982:80), postvocalic fortis singleton stops became lenited in Danish by about 1200AD unless they were adjacent to another fortis stop, and this change spread to parts of southern Sweden and Norway. Meanwhile, the lenis fricatives /v, ð, ɣ/ became glides /v/ > /w/; /ð, ɣ/ > /j/ after front vowels, /w/ after back vowels. Soon thereafter, the new voiced stops underwent spirantization and in some cases followed the old fricatives to become glides (e.g. *bage* [bæːɪ] above). Thus even though Danish behaves like other Gmc languages in prosodically prominent positions (i.e. the onset of stressed syllables) with regard to laryngeal activity, the laryngeal distinction has proven to be rather unstable in prosodically weak positions.

1.3.5. English

Lisker & Abramson (1964) is one of the most important early phonetic works on laryngeal contrasts in English (and other languages). They establish three types of stop voicing, namely prevoicing (negative VOT), short-lag (positive VOT), and long-lag (positive VOT). It is worth noting that in their study, all four English speakers consistently produced /p, t, k/ with a mean voicing lag of at least 60 ms, but in their production of /b, d, g/, one of the four speakers consistently had a mean voicing lead of around 90 ms while the other three had a short voicing lag. These findings are echoed by Flege (1982), whose study of the /p/~/b/ contrast in 10 male speakers of American English showed that three speakers produced /b/ with a short-lag VOT, three others produced either prevoiced or short-lag /b/, and the remaining four speakers consistently produced prevoiced /b/. Furthermore, Keating et al. (1983) note in their study that while /p, t, k/ are consistently aspirated and /b, d, g/ are generally voiceless and unaspirated, some of their speakers sometimes prevoice /b, d, g/. In a comparison of Chinese vs. British English stops, Deterding & Nolan (2007) find that both languages have similar VOT durations for /p, t, k/ and /b, d, g/ (though they represent the distinction in Chinese as aspirated /p^h, t^h, k^h/ vs. unaspirated /p, t, k/), but that British English shows a significantly higher percentage of voicing during the closure of (word-initial, postvocalic (V#___)) /b, d, g/: around 58% in British English /b, d, g/ vs. 17% in Chinese /p, t, k/. Docherty (1992:158) reports similar results for British English, with an average of 57% voicing in the closure of /b, d, g/, but he also reports that the majority of /b, d, g/ tokens (346 out of 372) had a short-lag VOT. These studies all suggest that while aspiration of /p, t, k/ is fairly consistent in English, voicing of /b, d, g/ is highly variable. However, Chen (1970) also shows that in English, more so than in other languages, the length of a preceding vowel is a robust indicator of the voicing of a following stop, with vowel length being around 50% greater before voiced than voiceless stops. (See also Henton et al. 1992.)

1.3.6. Dutch

Here again, Lisker & Abramson (1964) provide some relatively early acoustic measurements for Dutch. Their study shows that in the speech of a single Standard Dutch speaker, /b, d/ (*g* is realized as a velar fricative, not a stop) are produced with prevoicing of around 80 ms while /p, t, k/ are produced with a short voicing lag. However, van Alphen & Smits (2004) note that voicing in stops is not always consistent and there may be acoustical cues other than voicing that help to distinguish Dutch stops. In their study, prevoicing was present in only 75% of the tokens produced by 10 speakers, and one speaker produced only 38% with prevoicing. More recently, Simon's (2010) analysis of (Flemish) Dutch /b, d/ shows an average prevoicing of around 115ms, with 93% of tokens showing prevoicing. However, she also notes several studies that show that in Dutch, the 'voiced' fricatives /v, z, ɣ/ are usually produced without any voicing. In fact, Van de Velde et al. (1997) provide phonetic evidence that the LENIS fricatives /v, z, ɣ/ in northern standard Dutch (NSD) have become significantly less voiced since the 1930s, while the same fricatives in Belgian Dutch remain heavily voiced; subsequent studies have also noted widespread LENIS fricative devoicing (Kissine et al. 2003, 2005; Pinget 2015).[17] Iverson & Salmons (2003b) analyze Dutch as a mixed system, with the stops distinguished by voicing, perhaps due to Romance influence, and the fricatives more Germanic-like; this observation seems to be borne out by these studies, but some researchers are arguing that Dutch is

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[17] Robert Howell (p.c.) points out that there was already confusion of the graphemes <f> and <v> in the 17th century, suggesting that devoicing of Dutch /v, z/ goes back much further than the 1930s.

undergoing sound change, with the change more advanced in some varieties than others (van Alphen & Smits 2004, Pinget 2015; more on this in Chapter 4).[18]

1.3.7. German

An extensive study of German laryngeal contrasts is Jessen (1998). His study examines both stops and fricatives in a variety of contexts (intervocalic, utterance-initial, and post-voiceless (/ʃ/)) from what he describes as six Standard German speakers from North Germany. All speakers produce aspiration for /p, t, k/ in all positions, and all speakers partially voice /b, d, g/ in intervocalic position. For /b, d, g/ in utterance-initial position, however, two speakers produce no voicing, three speakers produce some voicing, and one speaker produces mostly voiced tokens. In post-voiceless position, three speakers produce some voicing. By way of contrast, the LENIS fricatives /v, z/ are at least partially voiced in all positions by all speakers, and are mostly or completely voiced in utterance-initial position by all but one speaker. Several other studies have looked at both stops (Jessen & Ringen 2002; Beckman et al. 2013) and fricatives (Beckman et al. 2009) specifically in intervocalic position and found similar results, i.e. the voicing of LENIS obstruents in this position is often complete, but also more variable than the lack of voicing in FORTIS obstruents. Additionally, Moosmüller & Ringen (2004) analyze six speakers of Viennese German and report that in word-initial position after a voiceless segment, both /b, d, g/ and /p, t, k/ are completely voiceless; however, they also note that intervocalically, /b, d, g/ show similar variability in voicing to other studies, though probably with less overall voicing. Finally, although German is typically considered an 'aspirating' language, Kohler (1979) reports that

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[18] Other Gmc languages that are reported to be 'voicing' languages like Dutch: Afrikaans (Wissing 1991), West Frisian (Tiersma 1985), Yiddish (Birnbaum 1979, Katz 1987), Scottish English (Wells 1982, Kohler 1979), and Rhineland German (Kohler 1979) (other references in Jansen 2004).

Rhineland German is like Dutch in that /b, d, g/ are voiced and /p, t, k/ are voiceless and unaspirated.

1.3.8. Swiss German

Swiss German differs from most other Germanic languages – indeed, from most languages – by having a stop contrast based on duration rather than voicing (Central Bavarian has a similar system; see Bannert 1977, Drake 2013, and further discussion in Chapter 5). This was first discussed by Winteler (1876), who also used the terms ‘fortis’ and ‘lenis’ to describe the contrast because both voicing and aspiration were absent, and mentioned closure duration, among other things, as being distinctive. Winteler’s early observations on the durational contrast have since been confirmed by numerous authors. For example, Fulop (1994) examines the /b, d, g/~/p, t, k/ contrast in word-initial, -medial, and -final positions from a single speaker of the Zürich dialect of Swiss German. The results of his study show that VOT is nearly identical for both FORTIS and LENIS stops (around 14 ms); aspiration occurs only word-finally, but for both LENIS and FORTIS stops; FORTIS stops are up to four times longer than LENIS stops; and in word-initial position, while there was no detectable difference in duration, there was a difference between FORTIS and LENIS in the post-release formant structure above F2. Willi’s (1996) account, also of the Zürich dialect, shows that while both FORTIS and LENIS stops are voiceless, FORTIS stops can be more than twice as long as LENIS stops in word-medial position (though this difference is apparently not as great as that noted by Fulop 1994 for the same dialect). However, the realization of the FORTIS-LENIS distinction differs across dialects of Swiss German: Marti (1985) notes that in the Bernese dialect area, word-initial stops are neutralized to LENIS in the north (/p/→/b/) and to FORTIS in the south (/b/→/p/) and Kraehenmann (2003) argues that in the Thurgovian dialect, the distinction is geminate-singleton rather than FORTIS-LENIS in all word positions, including word-initially. Finally, Ham (1998) shows in his analysis of (a dialect of) Bernese that there is a ternary surface length distinction between LENIS, FORTIS, and FORTIS geminate obstruents, but only word-medially and -finally. His results show that LENIS stops are between 80-110 ms, FORTIS stops between 160-190 ms, and FORTIS geminates between 220-290 ms (depending on the speaker), with similar results for word-final position (and for fricatives in the same positions), exhibiting a three-way length contrast in Bernese obstruents. Furthermore, Ham reports no significant difference in VOT, burst duration, or voice offset time for any of the obstruent contrasts in any word position (though there are a few individual speaker differences).

1.4. Conclusion

In summary, in PIE, both voicing and aspiration were contrastive based on standard reconstructions. At the very least, both voicing and aspiration were needed to distinguish the voiced aspirates $*b^h$, $*d^h$, $*g^h$ from the other stops; either *b, *d, *g were contrastively voiced (which seems to be the consensus) or *p, *t, *k were contrastively aspirated. The effects of Grimm’s Law suggest that PIE *p, *t, *k must have eventually developed aspiration before becoming PGmc fricatives *f, *þ, *h, followed by devoicing of the voiced series (PIE *b, *d, *g > PGmc *p, *t, *k) and deaspiration of the voiced aspirated series (PIE $*b^h$, $*d^h$, $*g^h$ > PGmc *b, *d, *g). Spirantization of the voiced stops and Verner’s Law then introduced voiced fricatives into the PGmc obstruent system; thus PGmc exhibited a stop/fricative contrast as well as a ‘voiced’/‘voiceless’ contrast for both stops and fricatives, which is a far cry from the PIE obstruent system. Subsequent developments in NGmc and WGmc further altered the obstruent systems, and one goal of this dissertation is to show how diachronic sound change has shaped the laryngeal contrasts in modern Norwegian, Dutch, and Swiss German.

In this dissertation, I aim to clearly distinguish phonetics and phonology. Ladefoged offers a succinct definition of each: “Phonetics is concerned with describing speech” (2006:1); and “Phonology is the description of the systems and patterns of sounds that occur in a language. It involves studying a language to determine its distinctive sounds, that is, those sounds that convey a difference in meaning” (2006:33). Phonetic description can refer to articulatory (e.g. [labial]) or acoustic (e.g. [sonorant]) properties of the speech sound, but the crucial point is that phonetic description is devoid of any reference to meaning or distinctiveness. Phonology, on the other hand, involves the organization of speech sounds into meaningful units based on certain, but not necessarily all, phonetic properties of those sounds. For example, /p, b, m/ are all articulated with a bilabial closure ([labial]), but only /m/ is acoustically [sonorant]; and /b/ and /m/ may both be produced with phonetic voicing, but if [voice] is predictable from [sonorant] (e.g. Stevens & Keyser 1989:83), then only [sonorant] is needed to distinguish /m/ from /b/ while [voice] may (or may not) distinguish /b/ from /p/. Phonology therefore relies on phonetics to a certain extent, but phonetics also operates outside of phonology; not all phonetic activity is relevant to phonology. This is by no means the only way of assigning the division of labor between phonetics and phonology (see Kingston 2007 for discussion), but it is the one adopted here, and is developed more fully in Chapter 2.

In terms of laryngeal phonetics and phonology, Section 1.3 above illustrates that the modern Germanic languages show a wide range of phonetic realizations of FORTIS and LENIS obstruents, and this variation is found not just between languages, but also between dialects – and individual speakers – of the same language. In other words, closely related languages and dialects that have inherited roughly the same obstruent system can vary wildly in the phonetic implementation of the LENIS/FORTIS contrast. One common theme is that aspiration of FORTIS stops is relatively consistent among the 'aspirating' languages while there is variability in the realization of LENIS stops – from completely voiced (Swedish) to completely voiceless (Icelandic) – and that voicing of LENIS stops is relatively consistent among the 'voicing' languages (Dutch). Additionally, as noted above, English /b/ can be articulated without any phonetic voicing and could therefore be phonetically identical to Dutch /p/, which is unaspirated; however, the phonology of each language determines that phonetic voicing of stops is phonologically contrastive in Dutch but not in English, where the phonetic gesture of aspiration is phonologically contrastive instead.

One aim of this dissertation is to address this type of asymmetry in the languages under discussion; specifically, I argue that the phonetic differences between 'aspirating' and 'voicing' languages are the result of an underlying privative specification (Section 2.6), and that the greater phonetic variability of certain segments is due to their being laryngeally unspecified ('laryngeal realism'; Section 2.7). I also argue that the phonetic variation in the realization of phonological contrasts can be due to phonetic enhancement (Section 2.10), but specifically that *redundant* features are used to enhance phonological contrast on a language- (or dialect-) specific basis according to the 'contrast and enhancement' model (Section 2.11). There are therefore diachronic, synchronic, phonetic, and phonological components of this dissertation;

diachronic change shapes the synchronic system, and phonetic enhancement increases phonological contrast.

This dissertation proceeds as follows: Chapter 2 presents the phonetic and phonological theoretical background, beginning with a discussion of the articulatory gestures responsible for voicing and aspiration, including how voicing is either maintained or inhibited in obstruent production. The phonetic component informs the phonological framework, which is based on privativity and underspecification as well as the model of contrast and enhancement mentioned above, where redundant features are employed to phonetically enhance phonological contrast; the specifics of the phonological framework are outlined in this chapter.

Chapters 3, 4, and 5 present experimental data for modern Norwegian, Dutch, and Swiss German obstruent systems, respectively, collected during fieldwork in the summer of 2013. I employed a sociophonetic approach to the fieldwork, with speakers recorded in their homes or a similarly casual setting rather than in a laboratory setting. This study was approved by the University of Wisconsin – Madison ED/SBS Institutional Review Board (ID 2013-0482). Each chapter begins with some additional diachronic background specific to the obstruent system of each language, followed by summaries of previous phonetic studies and phonological accounts for each language, followed by the experimental data and results. The results for Norwegian show that it is a typical ‘aspirating’ language, with aspiration, sonorant devoicing, and assimilation to voicelessness in clusters, but they also show that the FORTIS fricatives (including /s/) behave the same as the FORTIS stops, and I argue for a privative analysis where the FORTIS obstruents are specified for [spr gl] and the LENIS obstruents are laryngeally unspecified. The results for

Dutch are similar to some, but not all, previous studies; there are durational, voicing, and VOT differences between LENIS and FORTIS obstruents, but also a general lack of voicing assimilation in clusters (indeed, a general lack of any voicing in clusters). For a phonological analysis, it is unclear which feature, if any, is spreading; other studies (van Alphen & Smits 2004, Pinget 2015) have observed similar patterns and suggest that Dutch is undergoing sound change. Finally, Swiss German is shown to be a laryngeally unspecified language, with no difference in voicing or VOT and no sonorant devoicing for any obstruents, though there are clear durational differences, as expected. Furthermore, it is shown that length is contrastive for both vowels and consonants in Swiss German, and the two interact in interesting ways; the evidence supports a privative analysis for length.

Finally, Chapter 6 is the conclusion, where I summarize the findings, make comparisons between the three languages, and note suggestions for further research.

Chapter 2: Theoretical Background

2.1. Basic distinctions

Because the focus of this dissertation is laryngeal phonetics and phonology, it is important to understand the phonetic differences between sonorants and obstruents on the one hand and between 'voiced' and 'aspirated' obstruents on the other, so I begin this chapter by exploring the acoustics and articulatory gestures associated with each category; this provides the phonetic structure for the phonological framework discussed in the latter part of the chapter. Typically, the distinction between obstruents and sonorants is defined by degree of constriction between articulators and the effect it has on vocal fold vibration, such as this definition by Kenstowicz (1994:36):

> The [vocal] folds cannot vibrate if no air is passing through the glottis. In order for air to flow, the supralaryngeal pressure must be less than the sublaryngeal. The degree of stricture made during the articulation of a sound may increase the supralaryngeal pressure and hence tend to shut off voicing unless other adjustments are made. Stops and fricatives have a stricture that inhibits spontaneous voicing. The stricture associated with [+sonorant] segments does not disrupt airflow enough to inhibit voicing. Thus, the natural state for sonorants is [+voiced] and for nonsonorants…is [–voiced].[19]

This definition is goes back to the myoelastic-aerodynamic theory of phonation (van den Berg 1958) and essentially forms the basis of our understanding of voicing during speech. It is based on the fact that as the degree of stricture between articulators increases, the supralaryngeal air

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[19] See Botma (2011) for an overview of sonorant-related issues, such as sonorant obstruents and voiceless sonorants.

pressure builds up behind the stricture, which in turn inhibits vocal fold vibration; thus obstruents are essentially defined as being beyond the tipping point for spontaneous voicing.

This division is fairly uncomplicated for stops, affricates, and voiceless fricatives, but voiced fricatives can be problematic because they are sometimes spontaneously voiced. Indeed, /v/ in particular is notorious for patterning as both an obstruent and a sonorant, sometimes in the same language (e.g. Padgett 2002, Lulich 2004, and Vaux & Miller 2011:682-684 for /v/ in Russian; /v/ in Norwegian will be discussed in Chapter 3). Vaux & Miller (2011:684) cite Petrova's (1997) argument that "because labials have the largest oral cavity, they are the slowest to reach the translaryngeal pressure equilibrium that forces voicing cessation." (See also Westbury & Keating 1986:150.) This phonetic detail about voiced fricatives, and /v/ in particular, is important to the present discussion because even though LENIS fricatives can be spontaneously voiced, they usually pattern with other obstruents in devoicing assimilations; this is certainly the case in the languages investigated in this dissertation, as will be shown in subsequent chapters.

2.2. Voicing

Kenstowicz (1994:36-37) argues that because spontaneous voicing is the "natural state" for sonorants, an active laryngeal gesture is needed to produce voiceless sonorants (as in Icelandic, Section 1.3.1; voiceless sonorants will be discussed more below), and that because obstruents are "naturally" voiceless, some sort of gesture is required to lower the supralaryngeal air pressure to enable vocal fold vibration, especially in stops (as in Dutch). Johnson (2003:139) notes that larynx lowering, tongue-root advancement, and reduction of muscle tension in the cheeks and pharynx to allow for passive expansion are all gestures that can be used to lower supralaryngeal air pressure during stop closure to enable voicing to continue (see also Rothenberg 1968). Ladefoged & Maddieson (1996:50) also note that relaxing the cheeks and other soft tissues around the pharyngeal cavity allows for passive expansion, and that active gestures like moving the articulatory constriction forwards, advancing the tongue root, lowering the jaw, and lowering the larynx also lower the supralaryngeal air pressure. It appears, then, that there are both active (muscle tensing) and passive (muscle relaxing) gestures available to facilitate voicing during stop closure. In fact, in her study of three American English speakers, Bell-Berti (1975) found that both active and passive gestures were employed to allow for pharyngeal cavity expansion in the production of phonetically voiced medial stops, but that different strategies were used by each of the three speakers. These findings indicate that there are different ways of achieving vocal fold vibration during LENIS stop closure.

Similarly, Westbury (1983) notes both passive and active expansion of the supraglottal cavity as mechanisms that allow sustained transglottal airflow during stop closure. In his study of an American English speaker, he focuses on the active expansion of the supralaryngeal cavity by measuring the movement of the larynx, tongue root, velum, and tongue dorsum and tip. His results show that larynx lowering, tongue-root advancement, velum raising, and tongue dorsum and tip movements were all associated with the facilitation of voicing in LENIS stops, but to varying extents and in varying combinations depending on the place of articulation, phonetic environment, and position in the word. He states that “[t]he cumulative effect of articulatory movements on volume of the cavity above the glottis is more relevant to the problem of voicing maintenance during consonantal closure than are the direction and extent of movements of any single articulator” (1983:1331). He also notes that “[i]f it is more important during voiced stops to control whether (rather than how) the vocal folds oscillate, then all cavity-enlarging maneuvers whose magnitude and duration satisfy the boundary conditions necessary for oscillation can be considered equally well-suited for that behavioral goal" (1983:1333) and that "there are infinitely many ways to satisfy the boundary conditions for voicing during closure. Thus specifying only that a stop is [+voice] implies very little about how the cavity volume will be controlled in time" (1983:1335). It seems therefore that there is no single phonetic gesture that corresponds to the phonological feature [voice], but rather a bundle of possible and variable gestures.

Westbury also notes, however, that "the vocal folds will oscillate when they are properly adducted and tensed, and when a sufficient transglottal pressure gradient…is present" and that "the presence or absence of voicing depends largely upon the degree of vocal fold approximation and stiffness" (1983:1322). Thus the degree of vocal fold tension is also a factor, and this tension could be decreased during stop closure to increase vocal fold susceptibility to vibration; but it seems to be the case that vocal fold adduction and stiffness remain constant (1983:1323). Although a certain degree of vocal fold stiffness is apparently required for vibration, Stevens (1977:271) states that increased vocal fold stiffness can be used to inhibit voicing during the production of voiceless consonants, but also that the contraction of other muscles can slacken the vocal folds, a consequence of which is "the ability to maintain vocal fold vibration at low transglottal pressures, such as those occurring during voiced obstruent consonants." Thus, in addition to expansion of the supraglottal cavity discussed above, the laryngeal gesture of vocal fold slackening can also enable vocal fold vibration. Stevens also reports that stiff vocal folds are associated with a raised larynx (and thus a smaller supraglottal cavity) while vocal fold slackening is associated with larynx lowering (and thus a larger supraglottal cavity) (1977:272). Furthermore, according to Stevens (1977:276), combining stiff or slack vocal folds with a spread, neutral, or constricted configuration of the glottis (controlled by movement of the arytenoid cartilages; see e.g. Hirose 1977) results in voiceless or voiced aspirated, plain, or glottalized stops, respectively, as illustrated in Table 2.1:[20]

	Stiff vocal folds (raised larynx)	Slack vocal folds (lowered larynx)
Spread glottis	p^h	b^h
Neutral glottis	p	b
Constricted glottis	p’	ɓ

Table 2.1 Stop categories based on stiff or slack vocal folds and various states of the glottis; based on Stevens (1977:276)

2.3. Aspiration

While there seem to be several different mechanisms available for allowing vocal fold vibration during obstruent closure, the process of producing aspiration is more straightforward. Kim’s (1970) study of Korean stops shows that aspiration is directly related to the degree of glottal opening, not the timing of the glottal closure (Lisker & Abramson 1964), neither is aspiration the result of “heightened subglottal pressure” (Chomsky & Halle 1968). Korean stops are all voiceless and contrast between unaspirated, slightly aspirated, and heavily aspirated (Avery & Idsardi 2001, Ahn & Iverson 2004). The results of Kim’s cineradiographic study show a narrow glottal opening for unaspirated stops (ca. 1 mm), a moderate opening for slightly aspirated stops (ca. 3 mm), and a wide opening for heavily aspirated stops (ca. 10 mm), with average VOT values of 10 ms, 35 ms, and 90 ms, respectively. These results show that aspiration is a natural

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[20] See also Ladefoged & Maddieson (1996:50-51) for an overview of some of the literature cited here as well as additional literature, and further discussion of vocal fold vibration.

consequence of a spread configuration of the glottis, and aspiration duration is directly tied to the width of the glottal opening.

2.4. Fricative phonetics

Given the aerodynamic requirements for voicing outlined above and the basic definition of sonorants and obstruents, we would expect some similarities between stops and fricatives in terms of laryngeal gestures; however, we would also expect some differences due to the fact that fricatives are defined as having continuous, turbulent airflow. Continuous airflow is not a problem for voiceless fricatives if the glottis is open, but since vocal fold vibration entails closely approximated vocal folds that have a closure phase during vibration, airflow can be impeded for voiced fricatives. Stevens et al. (1992) point out that for voiced fricatives, adjustments must be made to the glottal configuration, the oral constriction, and/or the supraglottal volume for the production of both frication noise and vocal fold vibration. Thus there is the possibility of a trade-off between voicing and frication; this relates back to the discussion of /v/ above, which sometimes patterns as a sonorant, with perhaps more voicing and less stricture more generally. In fact, according to Maddieson (1984), for the 317 languages in the UPSID (UCLA Phonological Segment Inventory Database), 68.9% of the 1,112 occurrences of fricatives are voiceless, with the majority of the voiced fricatives being labial or, less often, dental.[21]

Moreover, Maddieson notes that the presence of voiced fricatives is almost always accompanied by the presence of voiceless fricatives, but rarely vice versa. This can be seen as evidence in favor of the notion that the default state for obstruents is voicelessness, and again this is likely

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[21] The division between 'voiced' and 'voiceless' obstruents is not based on any experimental phonetic evidence in Maddieson's study, so these figures are to be taken with a grain of salt.

due to the fact that the aerodynamic requirements for vocal fold vibration are not being met due to the buildup of air pressure behind the oral constriction. It is also worth pointing out that the percentage of voiceless fricatives is actually higher than the percentage of voiceless stops in the UPSID (61.3%), which is the opposite of what one would expect since transglottal airflow is only reduced for fricatives, not entirely blocked as it is for stops; thus it would seem that voiced fricatives should occur more frequently than voiced stops. Ohala (1983) explains that this is due to the fact that the requirements for voicing and frication are actually in competition. Specifically, low oral air pressure is required for voicing but a higher oral air pressure is required for frication.

Though there are a number of studies of laryngeal gestures for stops, there are fewer that specifically examine laryngeal gestures being used to produce voicelessness or maintain voicing in fricatives. One such study is Hirose & Gay (1972), which examines both stops and fricatives for two American English speakers. Their results show increased activity in the abductor, or glottal spreading, muscles for voiceless fricatives (as well as voiceless stops) and increased activity in the adductor muscles for voiced fricatives, but not as much as that observed for voiced stops, meaning that the glottis is not pulled as closely together during voiced fricatives as it is for voiced stops. Similar results are found in the laryngeal transillumination study by Lisker et al. (1969), where they show that voiced fricatives are produced with a fairly wide glottis; this is presumably to allow for the characteristic turbulent airflow of a fricative while still allowing a portion of the vocal folds to vibrate. More recently, Proctor et al. (2010) use magnetic resonance imaging to measure pharyngeal volume for voiced and voiceless fricatives in four American English speakers and find that voiced fricatives consistently have a larger pharyngeal volume for three of the four speakers. These studies show that similar gestures are used to enable voicing in voiced fricatives as are used for voiced stops, but that the glottis can be more open in voiced fricatives than it is in voiced stops to allow for greater oral airflow at the point of constriction.

2.5. Phonetics/phonology interface

This combination of phonetic laryngeal gestures discussed above – namely, vocal fold stiffness or slackness and glottal spreading or constriction – has formed the basis for numerous phonological accounts of laryngeal contrasts.[22] For example, Halle & Stevens (1971) use features that are based on the state of the glottis ([+/–spread] and [+/–constricted]) and of the vocal folds themselves ([+/–stiff] and [+/–slack]). Kenstowicz (1994) adopts [+/–spread] and [+/–constricted], but prefers the feature [+/–voice] over [+/–stiff] and [+/–slack], noting however that voicing is a function of glottal tension. Keyser & Stevens (2006) use binary [+/–stiff] in their discussion of laryngeal features while classifying gestures such as raising or lowering the larynx or spreading the glottis as sub-featural enhancement gestures that are used to help distinguish contrasting segments in perception.

While the enhancement component of the Keyser & Stevens (2006) model will be discussed later, I adopt here their model of the phonetics/phonology interface, which specifically addresses the relationship between discrete phonological representation and continuous phonetic realization. In this model, speech sounds begin as discrete representations in the phonology and progress through a series of stages until they end up as continuous sound at the surface phonetic level. At the representational level, segments are stored in the lexicon as discrete units with their

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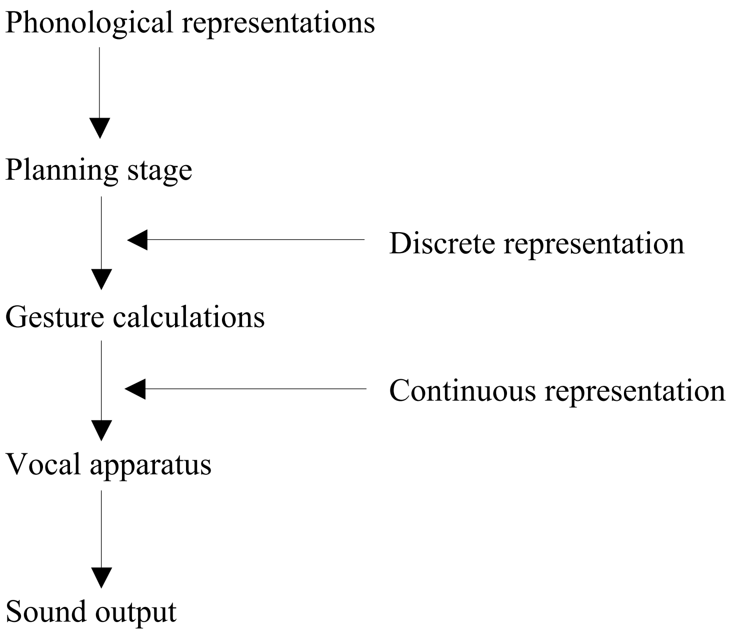
[22] Strictly speaking, active expansion of the supraglottal volume is not technically a laryngeal gesture since the larynx is not directly involved, though any gesture that enables the vocal folds to vibrate can contribute to a laryngeal distinction.

distinctive features. Next comes the planning stage, where segments are arrayed in the order they are intended to occur to match the lexical item.[23] Once the segments are arrayed, gesture calculations translate distinctive features into actual motor instructions that are sent to the muscles of the vocal apparatus (Keyser & Stevens 2006:35):

1)



It is at the gesture calculations stage where phonology ends and phonetics begins (2006:36). The example used by Keyser & Stevens is /t/, which in their framework has the features [+anterior, +consonantal, –continuant, –sonorant, +stiff vocal folds]. In terms of gesture calculations, this means that the blade of the tongue needs to make a complete closure with the alveolar ridge that is then released, and that the vocal folds need to be stiffened so that there is no vocal fold vibration (2006:36). This process converts discrete phonological input into continuous, analog phonetic output. Thus, in the model proposed by Keyser & Stevens, the laryngeal gestures described above for producing voicing, aspiration, or glottalization are the result of motor

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[23] They note that this is the stage where speech errors occur; one segment can be swapped for another, such as in metathesis (2006:35).

instructions encoded in the distinctive features that are stored with the relevant segments in the lexicon.

In the model proposed by Iverson & Salmons (1995), the relevant features for voicing, aspiration, and glottalization are simply [voice], [spread], and [constricted], respectively. Here, as in many other models, the feature [voice] can be seen as a cover term for the variety of gestures that enable voicing to continue during the production of an obstruent, whether it is slackening the vocal folds or expanding the supraglottal cavity in some way. In their framework, the features are privative, and a combination of these three features, plus laryngeal underspecification [ ], serve to distinguish the known types of laryngeal systems:

	/p/	/b/	/p^h/	/b^h/	/p'/	/ɓ/
Hawaiian	[ ]					
English	[ ]		[spr gl]			
Spanish	[ ]	[voice]				
K'ekchi	[ ]				[cnstr gl]	
Thai	[ ]	[voice]	[spr gl]			
Korean	[ ]		[spr gl]		[cnstr gl]	
Hausa	[ ]	[voice]			[cnstr gl]	
Hindi	[ ]	[voice]	[spr gl]	[spr gl] [voice]		
Yuchi	[ ]	[voice]	[spr gl]		[cnstr gl]	
Sedang	[ ]	[voice]	[spr gl]			[cnstr gl] [voice]
Zulu	[ ]		[spr gl]		[cnstr gl]	[cnstr gl] [voice]
Kullo	[ ]	[voice]			[cnstr gl]	[cnstr gl] [voice]
Sindhi	[ ]	[voice]	[spr gl]	[spr gl] [voice]		[cnstr gl] [voice]
Siswati	[ ]	[voice]	[spr gl]	[spr gl] [voice]	[cnstr gl]	
Beja	[ ]	[voice]	[spr gl]	[spr gl] [voice]	[cnstr gl]	[cnstr gl] [voice]

Table 2.2 Configurations of [voice], [spr gl], and [cnstr gl] in laryngeal contrasts (from Iverson & Salmons 1995:12)

This approach is supported by the experimental evidence found by Stevens (1977; also Hirose et al. 1972) where all six phonation types can be seen in Table 2.1 above. While the laryngeal configurations for plain (neutral), voiced (expanded supraglottal cavity and/or slack vocal folds), aspirated (spread glottis), and ejective (constricted glottis) stops have already been discussed, the laryngeal configurations for voiced aspirated (/b^h/) and implosive (/ɓ/) stops merit some explanation. For the voiced aspirated stop, Stevens notes a similarity to breathy vowels, where the glottis is spread in such a way that the anterior region of the vocal folds continues to vibrate while the posterior region is spread (1977:273-277). Hirose (1977:291-292) shows that the glottal width for /b^h/ is approximately half (or less) of that for /p^h/; nevertheless, the glottis is still open, so a phonological [spr gl] [voice] specification is justified on phonetic grounds. As for the voiced implosive /ɓ/, Stevens points out that vibration again occurs in the anterior region of the vocal folds, but that the posterior region is constricted (1977:274-277). Recall that in Stevens's model, voicelessness is due to stiff vocal folds, which in turn is associated with a raised larynx; and voicing is due to slack vocal folds, which in turn is associated with a lowered larynx. Therefore, with a constricted glottis, a raised larynx (and stiff vocal folds) produces the voiceless ejective /p'/ while a constricted glottis with a lowered larynx (and slack vocal folds) produces an implosive /ɓ/ as well as an expanded supraglottal cavity which enables voicing to occur; again, a phonological [constr gl] [voice] specification for /ɓ/ is justified on phonetic grounds.

Iverson & Salmons (1995) stress, in particular, that the two-way voicing contrasts found in languages like German and English cannot be based on the feature [voice] with aspiration added post-lexically by a phonetic rule. Building in particular on the work of Kim (1970) outlined above, they argue that because aspiration is the result of a spread configuration of the glottis, the feature [spr gl] is in the underlying representation for aspirated stops and FORTIS fricatives in languages like English and German while [voice] is the relevant feature for languages like Dutch, Slavic, and Romance. They cite as independent evidence of the necessity for both [voice] and [spr gl] the laryngeal systems of languages like Thai, where both features are used contrastively, and Hindi, where the features are used both contrastively and together, as outlined in Table 2.2 above.

2.6. Privativity

In addition to the phonetic evidence cited in Section 1.3 in favor of privative laryngeal features (for example, aspiration is more consistent and voicing more sporadic in most Germanic languages), there is also abundant phonological evidence supporting privative laryngeal features. Indeed, Honeybone (2005:5) states that “privativity is widely assumed in laryngeal phonology.” Iverson & Salmons (1995) also argue at length that laryngeal features are privative. For example, in Japanese “rendaku” compound voicing, an underlying voiceless obstruent becomes voiced when it is the first segment in the second element of the compound unless it is followed by a voiced obstruent in the same morpheme; if it is followed by a voiceless obstruent or a sonorant, rendaku voicing takes place (see Itô & Mester 1986, Mester & Itô 1989):

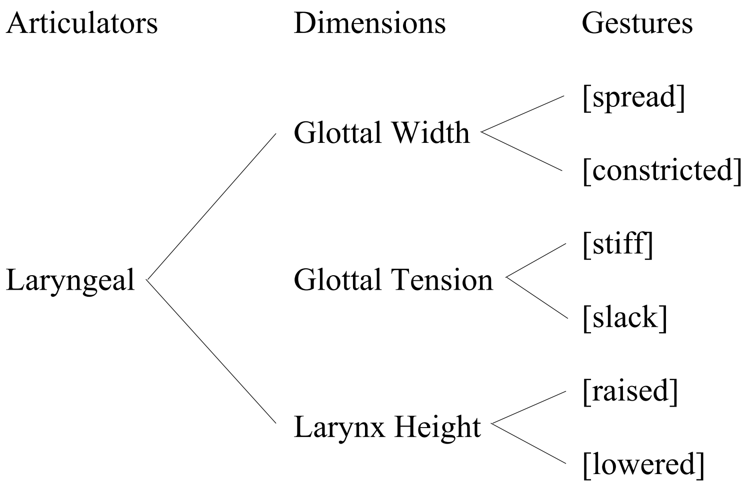
2) onna + kotoba → onnakotoba ‘feminine speech’ (no rendaku)
onna + kokoro → onna**g**okoro ‘feminine feelings’ (rendaku)
ori + kami → ori**g**ami ‘folding paper’ (rendaku)

In the first example, rendaku voicing is blocked by the presence of the *b* (underlined in the example); but in the second and third examples, rendaku voicing takes place because, as argued by Mester & Itô (1989), both sonorants and voiceless obstruents are unspecified for laryngeal features. Based on these and other examples, Mester & Itô argue that [voice] is universally privative and that there are no underlyingly voiceless ([–voice]) segments, noting that voiceless sonorants must be viewed as underlyingly aspirated ([spr gl]) rather than voiceless, or [–voice]. I provide evidence for this view of voiceless sonorants and discuss this in more detail below.

Iverson & Salmons (1995) take this one step further, arguing that not only [voice], but also [spr gl] and [constr gl] are privative. Whereas Mester & Itô use examples such as English plural formation (e.g. cat[s], dog[z]) to support privative [voice] for English (where [voice] is delinked from the /z/ in *cats*), Iverson & Salmons use the same kinds of examples as evidence of privative [spr gl] in English and other languages, where [spr gl] spreads from the /t/ in *cat* to the laryngeally unspecified plural morpheme /z/ → [s]. They also note that in languages like Japanese, Dutch, and Spanish, where /b, d, g/ are actually phonetically voiced and /p, t, k/ are unaspirated, the feature [voice] also participates in phonological processes like voicing assimilation; however, in languages like English, German, and Icelandic, /b, d, g/ are phonetically voiceless (or only passively or partially voiced) and /p, t, k/ are aspirated, but phonological devoicing assimilation occurs, which supports a privative [spr gl] analysis. Recall also from Section 1.3 that in all of the Germanic 'aspirating' languages (English, German, and all of NGmc), aspiration of /p, t, k/ was fairly consistent for all speakers; but for those speakers or dialects where phonetic voicing was present in /b, d, g/, voicing was inconsistent or sporadic, sometimes even for the same speaker. This is further evidence for a privative [spr gl] / [   ] contrast in these languages.

Avery & Idsardi's (2001) theory of laryngeal dimensions is organized around the antagonistic pairs of muscles in the larynx that are responsible for spreading and constricting the glottis, or stiffening and slackening the vocal folds, for example, as outlined in Stevens (1977) and above. Their model consists of a laryngeal node with three daughters: Glottal Width (GW), Glottal Tension (GT), and Larynx Height (LH). Each of these in turn has two dependents: GW has [spread] and [constricted], GT has [stiff] and [slack], and LH has [raised] and [lowered].

3)



(Avery & Idsardi 2001:42)

This captures the insight that the glottis cannot be both spread and constricted at the same time, nor can the vocal folds be both stiff and slack at the same time, but the vocal folds (GT dimension) and the glottis (GW dimension) can work independently and at the same time, allowing, for example, for the occurrence of voiced aspirates (which would employ both GT and GW).

Their model also relies on what they call "dimensional invariance", which is equivalent to privativity, but at the dimensional rather than the featural level; the cues for the marked member of a contrastive pair are relatively consistent and act as a signal to the contrastive dimension, while the cues for the unmarked member are more scattered (again, see the Section 1.3 for this type of asymmetry in Germanic). Additionally, they propose that only the dimensions (GW, GT, LH) are phonologically contrastive, not the features; each dimension has a default value (e.g. [spread] for GW) while the other feature can be used as a phonetic 'completion', to use their term, under certain circumstances. Moreover, their approach allows for one dimension to be used as a phonetic enhancement in a language where it is not otherwise contrastive; for example, GT (voicing) being used as a phonetic enhancement in a GW (aspirating) language. They also cite evidence from Korean to argue that only [spr gl], but not [constr gl], is phonologically contrastive in that language, noting that the 'tense' or unaspirated series is phonetically constricted but also phonetically long; they conclude that [long] is the phonologically contrastive feature for the 'tense' series but that it is completed with [constr gl] as a phonetic enhancement. Indeed, Kim (1970:109, f.n. 7) states that "[w]hat we normally call glottalized (or ejective) stops have a different phonation mechanism" than that of Korean unaspirated stops, which apparently never have a completely closed glottis (but yet still remain voiceless in spite of the close approximation of the vocal folds). Avery & Idsardi's insights into the organization of features into glottal dimensions, 'dimensional invariance' (privativity), and phonetic enhancement are relevant to the remaining discussion.

2.7. Laryngeal realism

Honeybone (2005) divides arguments over laryngeal representation into two traditions, labeled simply tradition (i) and tradition (ii). Tradition (i), or the 'standard' position (represented by e.g. Lombardi 1991) maintains that the laryngeal contrast between /p, t, k/ and /b, d, g/ is based on [voice] for English, German, Dutch, and other languages, and that surface aspiration of voiceless stops in English and German is derived by other phonetic or phonological processes. Tradition (ii) (represented by e.g. Iverson & Salmons 1995), which Honeybone calls 'laryngeal realism', argues that there is a fundamental difference in the underlying laryngeal specification for languages like English and German (which exhibit aspiration, sonorant devoicing, and assimilation to voicelessness) on the one hand and Dutch, West Frisian, and Yiddish (which have neither aspiration nor sonorant devoicing but exhibit voicing assimilation) on the other. Citing diachronic evidence as well as data from non-reference varieties of English and German, Honeybone argues that laryngeal realism can account for processes like delaryngealization (loss of a laryngeal feature; [spr gl] in his examples) in a straightforward way; English fricative 'voicing' is not the addition of [voice], but rather the loss of [spr gl], resulting in laryngeally unspecified segments.

Additional support for laryngeal realism comes from Kager et al. (2007), but instead of using the term 'laryngeal realism', they state it in terms of the Multiple Feature Hypothesis (i.e. tradition ii) versus the Single Feature Hypothesis (i.e. tradition i). In their study of child language acquisition, speech errors in Dutch and German tend to occur in the direction of the unmarked (or laryngeally unspecified) category. For example in Dutch, children produce plain voiceless (unmarked) stops when the target segment is specified for [voice] more often than they produce voiced (marked) stops when the target is a laryngeally unspecified plain stop. Similarly in German, [spr gl] targets are realized as plain unaspirated (unmarked) stops more often than laryngeally unspecified targets are realized as aspirated (marked). In both cases, marked targets are realized as unmarked more often than unmarked targets are realized as marked, but the marked feature is different in each language. According to Kager et al., "the result of neutralization to the unmarked value depends on the language-specific laryngeal feature: loss of [voice] for Dutch, and loss of [spread glottis] for German" (2007:74); tradition (i), on the other hand, would have predicted loss of [voice] in both languages. This makes sense if we think of obstruents as having a default state of voicelessness, with voicing and aspiration requiring extra gestures; their results indicate that the child language learners are simply omitting this extra (marked) gesture.

Finally, Kager et al. examine laryngeal harmony in the speech of a child learning American English, showing that word-initial ‘voiced’ targets are more likely to be realized as [spr gl] when followed by a [spr gl] obstruent than when followed by a ‘voiced’ obstruent or sonorant; it is particularly interesting to note that the results are identical for following ‘voiced’ obstruents and sonorants, which is an indication that both are unspecified for laryngeal features and only [spr gl] specified segments are able to trigger laryngeal harmony. In contrast, they found hardly any voicing harmony, where a [spr gl] target is realized as ‘voiced’ when followed by a ‘voiced’ obstruent, which is additional evidence that supports not only privativity, but laryngeal realism, where [voice] is redundant in English but [spr gl] is phonologically contrastive.

2.8. Sonorant features and sonorant devoicing

Based on the evidence presented above, I adopt the view that [voice] is redundant for sonorants, or in other words, that sonorants are unspecified for laryngeal features, as noted above, since voicing spontaneously occurs in sonorants. This is opposed to the active voicing of voiced obstruents in ‘voicing’ languages, where the extra gesture required to enable vocal fold vibration is an indication of an underlying [voice] specification. Instead, following Kaisse (2011) and others, I adopt a binary [+/–sonorant] specification for sonorants and obstruents, though nothing in the analyses of upcoming chapters crucially depends on this. As noted by many authors, the feature [sonorant] does not seem to be phonologically active, and several authors have argued against its inclusion as a distinctive feature on these grounds (see both Kaisse 2011 and Botma 2011 for references and further discussion). However, we need a feature that captures the insight that obstruents and sonorants pattern as natural classes, and so far no other feature has been posited, as far as I am aware, that does so any better than [sonorant]. Additionally, there does not seem to be any justification, or any need for that matter, for positing a privative [sonorant] feature, with obstruents somehow unspecified for that feature. Therefore, in the framework I adopt here, sonorants are specified as [+sonorant] because they exhibit spontaneous voicing and obstruents are specified as [–sonorant] because the degree of stricture inhibits spontaneous voicing. Again, nothing in my analysis crucially depends on this, but there is a need to distinguish sonorants from obstruents.

As for voiceless sonorants, Botma (2011:177) notes that "the presence of 'voiceless' sonorants in a language almost always implies the presence of aspirated stops," citing evidence from the UPSID database where all but two of the 24 languages that have voiceless nasals also have aspirated stops. In other words, one is much more likely to find voiceless sonorants in a language where there is also a glottal spreading gesture that produces aspiration, i.e. where [spr gl] is contrastive for the obstruents, than in a language that lacks aspiration. Thus, while it is unlikely that sonorants are ever underlyingly specified as [voice] (as argued by Itô & Mester 1986, Kiparsky 1985, Lombardi 1991, and others; see also Botma 2011:175-176 for an overview), they can be specified as [spr gl] in languages where [spr gl] is present in the obstruents.[24] In Icelandic, for example, both pre- and post-aspiration are prevalent, and there is also a voicing contrast in the sonorants (as noted in Section 1.3.1).

Botma (2011:177) also notes that voiceless sonorants often derive historically from obstruent-sonorant clusters (citing Burmese as an example), where the obstruent had a [spr gl] specification

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[24] This is also apparently true for the glottalized sonorants in Klamath, as noted above: plain voiceless stops contrast with both aspirated and ejective stops, and plain sonorants contrast with both voiceless and glottalized sonorants; Blevins (1993) uses the features [spr gl] and [constr gl] to mark this distinction for both stops and sonorants.

but subsequently became debuccalized, leaving only the [spr gl] specification that was then applied to the sonorant; presumably, there was some degree of sonorant devoicing before debuccalization took place. This is also the case in Icelandic, where the spelling of word-initial voiceless sonorants *hn*-, *hl*-, *hr*- reflects the PGmc development of PIE *kn-, *kl-, *kr-.[25] Iverson & Salmons (2003a:48) note: "As is now common practice, [spread] is the feature associated with the voiceless laryngeal approximant /h/ and with aspiration in stops and other consonants." As reviewed in Chapter 1, PIE voiceless stops became voiceless fricatives in PGmc, most likely through an intermediate stage of voiceless aspirated stops. In the case of PIE *k, it likely became debuccalized to /h/ word-initially (and in certain other positions) fairly early on, and also as noted in Chapter 1, it is usually transcribed as *h in all positions, whether laryngeal, uvular, or velar (or perhaps even palatal). Thus in Icelandic, all that was left of PIE *kn-, *kl-, *kr- after Grimm's Law (> *xn-, *xl-, *xr-) and debuccalization (> hn-, hl-, hr-) had taken place was the glottal spreading gesture associated with the feature [spr gl]. Debuccalization had also taken place in other Germanic languages, but only in Icelandic has the glottal spreading gesture been retained as part of the phonological specification of the remaining sonorant. Spontaneous voicing is inhibited in these sonorants, not because of an increase in air pressure due to a constriction in the supralaryngeal cavity as is the case with stops, but because of the glottal spreading gesture that prevents the vocal folds from even making contact; the air simply passes through the larynx and continues through the oral or nasal cavity.

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[25] See Botma (2011:177-178) for further discussion of the arguments for and against classifying voiceless sonorants as either sonorants or fricatives (Ladefoged & Maddieson 1996:198-199 argue that both types exist and that there is a phonetic difference between the two). See also Bombien (2006) for a phonetic analysis of voiceless sonorants in Icelandic.

If voiceless sonorants are the result of a debuccalized [spr gl] segment, then the pre-debuccalization clusters likely exhibited sonorant devoicing at some point. Sonorant devoicing, where a sonorant becomes partially or completely devoiced following an aspirated stop or voiceless fricative, has been observed in numerous aspirating languages including English (e.g. Klatt 1975, Docherty 1992) and German (e.g. Hoole et al. 2003, Hoole & Bombien 2014). In fact, as noted above, sonorant devoicing, along with aspiration and assimilation to voicelessness, are the criteria used in laryngeal realism to determine whether a language is a [spr gl] language as opposed to a [voice] language, which exhibits voicing assimilation but neither aspiration nor sonorant devoicing. According to laryngeal realism, we hear aspiration in a word like *pan* [pʰæn] because the vocal folds are still abducted following the production of the initial /p/, but a word like *ban* will have a phonetically voiceless [b̥] or [p]. Sonorant devoicing is explained in the same way; a word such as plan [pʰl̥æn] exhibits at least partial devoicing of the /l/ because the vocal folds have been pulled apart for the /p/ and have not yet come back together again to voice the /l/. Under this analysis, we would expect any language that exhibits aspiration after a voiceless stop to also exhibit sonorant devoicing in the same environment because of the abducted state of the vocal folds during the production of FORTIS obstruents. So the underlying specification of /p, t, k/ with [spr gl] in the phonology translates into an actual physical gesture of spreading the vocal folds during production, with aspiration and sonorant devoicing as results. In the case of sonorant devoicing, the glottal spreading gesture continues through at least part of the production of the sonorant, and it is not blocked due to the lack of an active voicing gesture encoded in the specification of the sonorant. However, sonorants are by definition spontaneously voiced, so after the glottal spreading gesture has been completed, the vocal folds return to a state of spontaneous voicing. In this dissertation, 'sonorant devoicing' does not necessarily entail the complete devoicing of a sonorant from start to finish, but rather, it is an indication of a spread glottis and may only entail partial devoicing.

2.9. Fricative features

According to Vaux & Miller (2011), the traditional featural specification of fricatives, going back to Jakobson et al. (1952), is [–son, +cont]. Vaux & Miller state that "[c]ontinuants can be defined straightforwardly as sounds with oral airflow egress, and obstruents as sounds with positive oral pressure buildup. Fricatives conform to both of these definitions, so there is no difficulty in correlating the feature specification of fricatives with well-established phonetic cues" (2011:673); as such, this phonological specification of fricatives as [–son, +cont] is sufficient for our purposes here since it agrees with the articulatory considerations for fricatives discussed in Section 2.4. As noted above, I am adopting a binary [+/–son] to mark the distinction between sonorants and obstruents; I also adopt here a binary feature [+/–cont] to mark the distinction between stops ([–cont]) and fricatives ([+cont]) for the languages being examined in this dissertation.

Vaux & Miller cite several examples of stopping and spirantization to illustrate that [cont] is phonologically active, arguing that vowels (and other sonorants) are phonologically specified as [+cont] which spreads to [–cont] stops in the case of spirantization. While noting that Jakobson et al. (1952) and Chomsky & Halle (1968) represent vowels as unspecified for [cont], Vaux & Miller explore the question of whether spirantization can be analyzed as phonological spreading of [+cont] from vowels to [–cont] stops, citing Dresher's (2009) Contrastivist Hypothesis which allows non-contrastive features to participate in phonological processes. An analogous process can be found in intervocalic voicing. If we assume that vowels are unspecified for laryngeal features but are spontaneously voiced, then phonetic voicing spreads to laryngeally unspecified /b, d, g/ (which are otherwise voiceless) in certain environments. By the same token, if both vowels and /b, d, g/ are unspecified for continuancy, then [cont] spreads phonetically to /b, d, g/ from the vowels (a process called ‘passive spirantization’ by Iverson & Salmons 2003a, discussed in Section 1.2.2). If, however, /b, d, g/ are underlyingly specified as [–cont] (while the vowels remain unspecified), we would expect no spirantization to occur. This appears to be the case in the languages being investigated here.

In terms of laryngeal features for fricatives, Vaux (1998) notes that while the bulk of the work on laryngeal phonology focuses on the stops /b, d, g/ and /p, t, k/, an examination of fricatives reveals interesting differences. As argued extensively by Vaux, fricatives behave differently from stops, and the laryngeal contrast in the fricatives may be based on a different feature than that of the stops within the same language. Specifically, he argues that the unmarked laryngeal specification for voiceless fricatives in any language is [spr gl]. This contrasts with stops, where the unmarked specification is language-specific and could be based on voicing, aspiration, or glottalization. He also mentions that his theory is intended to have phonological rather than phonetic consequences (1998:509); in other words, voiceless fricatives are phonologically specified as [spr gl] unless prevented from being so by some language-specific constraint.

Avery & Idsardi’s (2001) theory of laryngeal dimensions includes the concept of enhancement as well as Vaux’s (1998) insights on voiceless fricatives. As noted above, the glottal dimension is ‘completed’, to use their term, with a laryngeal gesture, such as [spr gl] under a GW dimension.

This differs from enhancement, however, which is the insertion of an additional dimension node along with that node's default completion (recall that [spread] is the default for GW, [slack] for GT). Thus they define Vaux's Law as "ensur[ing] that fricatives are enhanced with GW whenever possible" (2001:48), or in other words, Vaux's Law is a phonetic enhancement that obligatorily adds [spr gl] to voiceless fricatives. They also add that Vaux's Law "is suspended in cases where GW is contrastive for fricatives" (2001:48), meaning that if a given language has a GW contrast in the fricatives, there is no need for Vaux's Law to take effect. And finally, they make a prediction that "the only systems in which we would expect to find true plain fricatives are those…that employ GW contrastively" (2001:48). This bears directly on the discussion of the laryngeal systems to be discussed in subsequent chapters of this dissertation, where all three languages have voiceless fricatives. Whether GW (or [spr gl]) is contrastive for fricatives in these languages will be investigated in subsequent chapters.

2.10. Enhancement

The studies on laryngeal gestures cited at the beginning of this chapter contain data, in many cases, on LENIS obstruents in American English, and these studies clearly show laryngeal muscle activity and/or active expansion of the supraglottal cavity during the closure of these obstruents in order to maintain voicing. Based on these findings, one might conclude that privative [voice] is the relevant feature in English and that laryngeal realism is invalidated. However, the studies cited above also clearly show active glottal spreading gestures for FORTIS obstruents, and several studies, e.g. Lisker & Abramson (1964), have shown that LENIS obstruents are inconsistently voiced and more often voiceless. We have also noted that the 'aspirating' languages are characterized by a series of aspirated voiceless stops, sonorant devoicing, and devoicing assimilation while ‘voicing’ languages are characterized by a series of fully voiced obstruents, no aspiration of voiceless stops, no sonorant devoicing, and voicing assimilation. However, if we intend to hold to laryngeal realism (or privativity, for that matter), then we need to account for the presence of active gestures in the production of the phonologically unspecified series of obstruents; phonetic enhancement is a promising solution to this dilemma.

Keyser & Stevens describe enhancement as follows: “In a given language the sound output generated by…feature-defining gestures…may lack saliency. In these cases the perceptual saliency may be enhanced by introducing gestures secondary to the feature-defining gestures” (2006:38). In other words, when the distinctive features of a given phoneme are only slightly different from the distinctive features of another phoneme, the distinction between them can be enhanced by the addition of one or more gestures that are otherwise not a part of the set of distinctive features for those segments in the phonology. The example they use to illustrate this is the presence of lip rounding in English /ʃ/. This lip rounding helps to distinguish /ʃ/ from /s/ (which otherwise differ only by /ʃ/ being [-anterior]) by extending the front cavity, which in turn accentuates the prominence of the third formant (an acoustic correlate of [-anterior] fricatives). Since /ʃ/ can also be produced without lip rounding and still be recognized as /ʃ/, the presence of lip rounding is seen as a phonetic enhancement rather than a distinctive feature.

In Keyser & Stevens’s (2006) model, enhancement is a language-specific process that runs parallel to the universal process of converting lexical phonemes into speech output through the planning stage, gesture calculations, and vocal apparatus, as outlined below (2006:39, 53, 58):

4)

Language-specific component	Universal component
	Phonological representations
Enhancement	Planning stage
Enhancement gesture calculations	Gesture calculations
	Overlap
	Vocal apparatus
	Sound output

The enhancement component interacts with the planning stage and flags distinctive features that lack perceptual saliency. For those features that are flagged, additional enhancement gestures are calculated at the same time as the gesture calculations are taking place for the distinctive features.

Keyser & Stevens make a few additional observations about the difference between distinctive features and enhancement. One is that speech errors never seem to target enhancement gestures alone; the rounding gesture for /ʃ/ never accidentally appears on /s/, for example (2006:39-40). Another observation is that enhancement gestures are more variable and gradient than gestures associated with distinctive features, and the example they use is that the degree of rounding for /ʃ/ is more variable than it is for /u/, for which [round] is a distinctive feature (2006:40). I would also add that the degree of backness for /u/ is quite variable and that it can be considerably fronted in many varieties of English (Hall 2011:18), which supports the view that [round] is distinctive for /u/ because it is always present and consistent while [back] (which is more variable) can be used as an enhancing feature.

Keyser & Stevens's framework accounts for phonetic variation with the concept of phonetic enhancement, and one type of variation is overlap (2006:36-37). The example they use is *top tag*, where the bilabial closure of the /p/ can often eclipse the alveolar closure of the /t/. In this case, when the bilabial closure is released, the alveolar closure of the /t/ has already begun, and any acoustic evidence of the release of /p/ or the closure of /t/ is absent. Another example is the realization of /n/ as velar [ŋ] in *in case*. In this example, the velar closure of the following /k/ is overlapping (or in extreme cases, simply replacing) the alveolar closure for the preceding /n/. Thus, assimilation processes, either progressive or regressive, can be seen as instances of articulatory overlap.[26]

This leads to the observation made by Keyser & Stevens that enhancement gestures are not subject to overlap while gestures associated with distinctive features are (2006:54). One example they use to illustrate this is the devoicing of the vowel in the first syllable of the word *potato*. In their view, the devoicing of this vowel is due to a combination of several factors: 1) it is a reduced vowel in an unstressed syllable, and 2) it is preceded and followed by two stops that are 3) specified as [+stiff vocal folds] (i.e. voiceless) and 4) enhanced with a spread glottis gesture. Thus the enhancement gestures of spreading the glottis for both /p/ and /t/ overlap to the point that they become a single gesture. As they explain:

> The enhancement gestures are preserved in spite of this overlap and are not truncated to permit voicing to occur in the vowel. In this case, it is important to note that enhancement gestures survive overlap while feature-initiated ones are severely weakened. (2006:54)

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[26] See Browman & Goldstein (1986, 1992) for another account of gestural overlap in the Articulatory Phonology framework.

However, this is only true if we accept that a) [voice] is a distinctive feature for vowels, and b) glottal spreading is an enhancement gesture for voiceless stops. Both points are problematic based on the evidence provided so far in this chapter; I have argued that [voice] is redundant for vowels and that [spr gl] is distinctive for obstruents in 'aspirating' languages like English. While the argument for using [+stiff vocal folds] to express voicelessness may have some merit on phonetic/articulatory grounds, in the analysis presented here, the devoicing of the unstressed vowel in *potato* can be explained by the phonologically distinctive feature [spr gl] of /p/ and /t/ completely overlapping the redundant voicing of the intervening unstressed vowel. Thus, while I generally agree with the model of speech production presented by Keyser & Stevens (2006), including enhancement, it does not seem to be the case that distinctive feature gestures are subject to overlap. In fact, the contrast and enhancement model discussed in the following section argues almost the opposite of what Keyser & Stevens propose: distinctive features induce assimilation/overlap while redundant features are subject to it; there are, however, some qualifications, such as the relative ordering of features and other language-specific rules.

2.11. Contrast and enhancement

Hall (2011) presents a model of contrast and enhancement that fuses the model of speech production and enhancement presented by Keyser & Stevens (2006) with a model of phonological contrast presented by Dresher (2009). At the core of Dresher's model is the theory of Modified Contrastive Specification (MCS), and at the core of MCS are the notions that:

5) a. only those features that serve to distinguish underlying phonemes are contrastive,

   b. features are determined to be contrastive or redundant according to a language-specific hierarchical ordering of features,

c. phonemes are only specified for contrastive features, and

d. phonological processes tend to target contrastive features while ignoring redundant ones (Hall 2011:12,14; Dresher 2009)

As Hall (2011:3) explains, “The idea at the core of this approach is a simple one: if all phonologically encoded features are contrastive, then enhancing these features enhances contrast.” The language-specific hierarchical ordering of features is accomplished by the Successive Division Algorithm (SDA) as outlined below (Hall 2011:13, Dresher 2009:16):

6) The Successive Division Algorithm

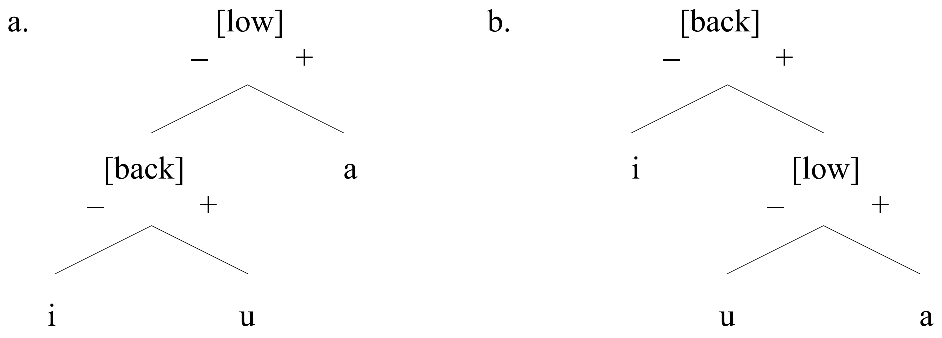
a. Begin with no feature specifications: assume all sounds are allophones of a single undifferentiated phoneme.

b. If the set is found to consist of more than one contrasting member, select a feature and divide the set into as many subsets as the feature allows for.

c. Repeat step (b) in each subset: keep dividing up the inventory into sets, applying successive features in turn, until every set has only one member.

In a simple example to see how the SDA works, Hall discusses the features [low] and [back] in a three-vowel inventory /i, a, u/ (Hall 2011:13):

7) Divisions



Feature specifications

	i	a	u
[low]	–	+	–
[back]	–		+

	i	a	u
[back]	–	+	+
[low]		+	–

Hall clarifies that “[w]hichever of the two features takes wider scope is necessarily contrastive for the entire inventory, and so all three segments have specifications for [low] in [(7a)], and for [back] in [(7b)]” (2011:13). Hall continues to explain that the first division separates one segment from the other two (/a/ as [+low] in (7a), /i/ as [–back] in (7b)), and that segment is now unique and receives no further specification. Meanwhile, the second feature takes narrower scope and serves to distinguish only those segments that remain undifferentiated after the first division because they share the same specification of that feature; [back] is only contrastive for the two [–low] segments in (7a) and [low] is only contrastive for the two [+back] segments in (7b). This model therefore relies on some form of feature underspecification. The prediction here is that since /a/ in (7a) is unspecified for the feature [back], its backness might show some variability; and since /i/ in (7b) is unspecified for the feature [low], its height might be more variable. Thus the relative ordering of features is not set by the SDA but is language-specific, allowing for cross-linguistic variation, and predicting where that variation will occur based on feature ordering and underspecification.

However, if we consider that /i/ is both [–low] and [–back] in (7a), and /a/ is both [+low] and [+back] in (7b), then it would seem that [–low] is predictable for /i/ and [+back] is predictable for /a/, since only /u/ requires different values for each feature. If we eliminate [–low] for /i/ and [+back] for /a/, then it would seem that all segments are distinct from one another:

8) Full specification:

	i	a	u
[low]	–	+	–
[back]	–	+	+

All predictable features eliminated:

	i	a	u
[low]		+	–
[back]	–		+

At first glance, this seems to work, and no hierarchical ordering of features is needed; /i/ is distinct from /a/ and /u/ by being [–back], /a/ is distinct from /i/ and /u/ by being [+low], and /u/ is distinct from /i/ and /a/ by being both [–low] and [+back]. Dresher (2009) describes this approach as the 'pairwise method' because it successfully divides the inventory into minimal pairs. However, both Dresher (2009) and Hall (2011) raise the question of how /i/ and /a/ form a minimal pair in this case – specifically, how does a feature specification of [–back] contrast with a feature specification of [+low]? Hall takes this line of thinking to its logical conclusion with the following example (Hall 2011:14):

9) Full specification of /i a u/ for four features

	i	a	u
[high]	+	–	+
[low]	–	+	–
[back]	–	+	+
[round]	–	–	+

It can be seen here that no segment differs from any other segment by virtue of a single feature value. The features [high] and [low] cancel each other out because the value of one feature is predictable from the other. Similarly, the values for [back] and [round] are mutually predictable for both /i/ and /u/. Finally, the fact that /a/ is the only [-high] (or [+low]) segment predicts that it is also the only segment that is both [+back] and [-round]. In other words, there are no minimal pairs. Notice also that the pairwise method similarly fails with only three features:

10)	i	a	u	OR:	i	a	u
[low]	–	+	–	[high]	+	–	+
[back]	–	+	+	[low]	–	+	–
[round]	–	–	+	[back]	–	+	+

As pointed out by Hall (2011:14), "[t]he crucial insight of the SDA is that any 'predictable' feature value is predictable only *in light of* other feature values." In other words, eliminating all predictable features, based on a contrast of minimal pairs, ultimately leads to an untenable definition of contrast. This is seen in the examples above, where /i/ and /a/ form an awkward minimal pair, or where the value of one feature was predictable from another such that there were no minimal pairs left. The hierarchical ordering of features provided by the SDA overcomes these obstacles by ensuring that all segments are maximally distinct with the minimal amount of specification.

This brings us to the final core idea behind MCS, which is that phonological processes have a tendency to ignore redundant features and target contrastive ones. Hall cites Finnish vowel harmony as an example (2011:14-15). In Finnish, /i/ and /e/ are transparent to vowel place harmony, where the suffix vowel agrees with the frontness or backness of the first vowel in the root; notice that an intervening /i/ or /e/ have no effect (Hall 2011:14; Hall's notation):

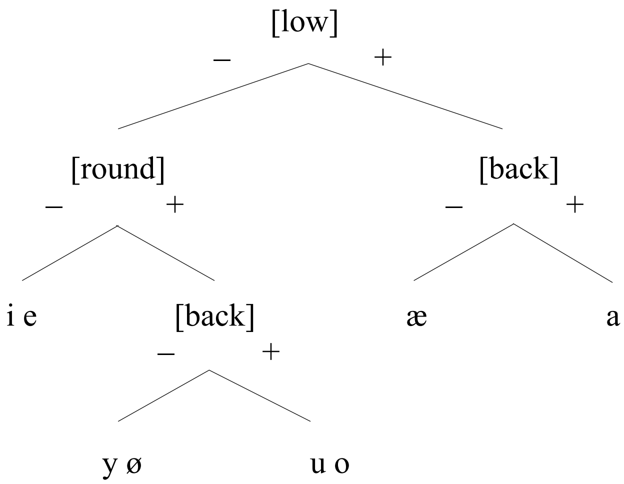
11)	a. [grøtsi+næ]	'porridge + ESSIVE'
	[tsaari+na]	'tsar + ESSIVE'
	b. [syyte+ttæ]	'action + ABESSIVE'
	[suure+tta]	'entry + ABESSIVE'
	c. [væitel+lyt]	'dispute + PAST PART'
	[ajatel+lut]	'think + PAST PART'
	d. [værttinæ+llæ+ni+hæn]	'with spinning wheel, as you know'
	[palttina+lla+ni+han]	'with linen cloth, as you know'

Hall notes that in the Finnish vowel inventory, /i/ and /e/ both lack back counterparts but /y, ø, æ/ contrast with /u, o, a/ (2011:15):

12)	front		back	
	unrounded	rounded	unrounded	rounded
high	i	y		u
mid	e	ø		o
low	æ		a	

While it is not automatically the case that a gap in the inventory necessarily entails a lack of contrast for the relevant segments, Hall argues that the phonological behavior of /i/ and /e/ with respect to vowel harmony suggests that they are unspecified for [back] features, and this is corroborated by the fact that they also lack [+back] counterparts in the inventory. Hall then proposes the following contrastive hierarchy to reflect this behavior, where [back] takes narrower scope than either [low] or [round] (noting that the relative ordering of [low] and [round] is not crucial) (2011:15):

13)



Notice here that /i/ and /e/ are specified as [–low] and [–round], but are otherwise unspecified for [back], which explains why they are transparent to [back] harmony as demonstrated in (11) above. Since MCS assumes underspecification, then predictable/redundant features must be filled in somewhere. This, Hall argues (2011:16-19), is accomplished by the theory of phonetic enhancement proposed by Keyser & Stevens (2006), as outlined in the previous section. As noted above, enhancement is variable while distinctive features are categorical (Keyser & Stevens 2006:40); thus if /u/ is specified for [round], then [back] can be used as an enhancement (English), or vice versa (Spanish; Hall 2011:18). Phonetic variability is therefore used as a diagnostic as to whether a given feature is contrastive or redundant. An additional diagnostic is stated in (5d) above, as part of MCS: phonological processes tend to target contrastive features while ignoring redundant ones. Hall (2011:18) cites voicing assimilation as an example, which often targets obstruents to the exclusion of sonorants, and natural classes pattern together in such processes. Hall posits the following theory of contrast and enhancement (2011:19):

14) a. Phonological feature specifications are assigned by the Successive Division Algorithm

b. Only these contrastive feature specifications are phonologically active

c. In phonetic implementation, redundant properties of segments tend to be filled in in ways that enhance the auditory impression of their contrastive features.

d. Phonetic enhancement is variable across languages, speakers and contexts, and the distinctness of phonemes is sometimes reduced by other factors, such as articulatory overlap (Stevens & Keyser 2010:§4).

Thus Dresher's (2009) model of phonological contrast is combined with Keyser & Stevens's (2006) insights on phonetic enhancement to account for phonetic variation as well as predict which features are contrastive and which are used as enhancements. Furthermore, Hall (2011:20) lists several ways redundant features can be used to increase phonological contrast, as in (14c) above:

15) a. by the amplification of its articulatory and acoustic/auditory correlates ([–back] realized as front as opposed to central)

b. by the addition of an articulatorily distinct gesture that produces a similar acoustic/auditory effect (backness and rounding both lower F2)

c. by an articulatorily distinct gesture that enables (15a) or (15b) (a [–back] or [+back] vowel can be enhanced by being realized as high, because the upper part of the vowel space permits a wider range of variation in F2)

d. by the amplification of a natural mechanical by-product of that gesture (a [+ATR] vowel can be enhanced by a higher or more forward tongue body)

e. by a separate acoustic/auditory effect that increases the relative salience of that correlate (producing a contrastively [+low] vowel with lower pitch increases the degree to which F1 is higher than F0)

Notice that Hall uses binary features in his examples, but that I am arguing for privative laryngeal features. Hall addresses this issue, noting that the contrast and enhancement model can also accommodate privativity, because "[a]t each branch [of the contrastive hierarchy], the absence of the feature at issue is interpreted as contrastive, and thus subject to enhancement" (2011:40). Applying this to laryngeal phonology, if we consider [spr gl] as a specification of glottal abduction (glottal spreading) and [voice] as a specification of glottal adduction (voicing), then segments that are unspecified for glottal abduction ([spr gl]) can be enhanced with glottal adduction (voicing), and segments that are unspecified for glottal adduction ([voice]) can be enhanced with glottal abduction (devoicing). Thus enhancing phonological contrast also applies to segments that are contrastively unspecified. Hall also suggests an alternative proposal that "the contrastive absence [of a feature] would not be subject to enhancement…, being at most constrained not to encroach on the…territory" of the specified feature (2011:41). Under this analysis, a laryngeally unspecified segment could be articulated anywhere along the adduction/abduction continuum as long as it did not encroach on the territory of the [voice] or [spr gl] segment. Based on the evidence in Section 1.3, it seems both options are available: Swedish uses [voice] as a phonetic enhancement in its contrastively unspecified segments while Icelandic and Danish do not; recall that Icelandic /b, d, g/ are completely voiceless and that Hutters (1985) finds a small glottal spreading gesture for /b, d, g/ in Danish, thus glottal abduction is occurring, but not to the same extent as (aspirated) /p, t, k/. (Notice that this is essentially the same as Avery & Idsardi's model above, where GW can be used as an enhancement in GT systems and vice versa.)

Furthermore, according to Hall,

> The representational economy of the contrast and enhancement theory resides in the fact that the SDA can assign to any inventory only the features that are required to differentiate its segments. This means that it cannot assign to the inventory…any of the features that the segments have in common, but also that it cannot assign to the inventory…all of the features in which the segments differ. (2011:37)

Thus in this model, segments are minimally specified but maximally differentiated. Crucially, in terms of laryngeal phonology, this means that if a language has a devoicing gesture for /p/ and a voicing gesture for /b/, only one of them will be contrastive in order to differentiate the two, rather than both /p/ being specified for [spr gl] and /b/ being specified for [voice].

This model can shed light on some otherwise perplexing cases of non-contrastive features being prominently realized in certain languages. To cite Swedish again, Helgason & Ringen (2008) report that Central Standard Swedish exhibits both aspiration of /p, t, k/ and robust voicing of /b, d, g/, leading Helgason & Ringen (2008) and Beckman et al. (2011) to argue for laryngeal overspecification in that language; i.e., both FORTIS and LENIS obstruents carry an underlying laryngeal specification. However, Helgason & Ringen (2008) also report that both inter-speaker and gender differences in the voicing of /b, d, g/ were significant, but that neither inter-speaker nor gender differences in the aspiration of /p, t, k/ were significant, which is an indication that aspiration is more consistent than voicing in Central Standard Swedish. Additionally, Helgason

& Ringen (2008:622) note that when any member of an obstruent cluster is FORTIS, the entire cluster is voiceless; only clusters in which both members are LENIS are fully voiced. The fact that only devoicing assimilation occurs in obstruent clusters is evidence that [spr gl], but not [voice], is phonologically active in this language. These findings suggest that [voice] is a phonetic enhancement rather than a distinctive feature in Central Standard Swedish.

A similar example is found in Japanese. Citing evidence from rendaku compound voicing, Avery & Idsardi (2001) argue that the GT dimension (or [voice] in a featural analysis) is contrastive in Japanese. However, they also discuss Japanese high vowel deletion, where high vowels are often deleted between two voiceless obstruents. Furthermore, they cite phonetic studies by Hirose & Ushijima (1978) and Yoshioka et al. (1982) that show a glottal spreading gesture is present in Japanese voiceless obstruents. Avery & Idsardi propose that Japanese high vowel deletion is the result of phonetic enhancement of [spr gl] (or GW in their framework) in an otherwise [voice] (or GT) language. As further evidence that the presence of [spr gl] is phonetic, they cite Tsuchida (1997) who notes that high vowel devoicing is highly variable in Japanese. Thus Japanese and Swedish are essentially opposites: [spr gl] and [voice] are phonetically salient in both languages, but [voice] is variable and [spr gl] is phonologically active in Swedish whereas [spr gl] is variable and [voice] is phonologically active in Japanese.

Finally, Hall mentions that “[m]any phonological patterns arise diachronically through the phonologization of natural phonetic processes” (2011:46). This brief comment lends itself to the suggestion that phonetic enhancement, too, can become phonologized, and that phonological contrast can be reanalyzed as phonetic; I adopt this diachronic aspect of the contrast and enhancement model to account for some of the sound changes observed in subsequent chapters.

2.12. Conclusion

In summary, then, laryngeal gestures, laryngeal realism (including privativity), enhancement, and contrast all feed into the model proposed here. As noted above for Swedish and Japanese, the presence of both active voicing gestures and active glottal spreading gestures in the same language does not necessarily mean that these gestures both correspond to underlying distinctive features. Additionally, privativity and laryngeal realism by definition leave segments unspecified for certain features; this means they are susceptible to variation in certain phonetic and phonological contexts and can undergo phonological processes, and this is not the same as phonetic enhancement, which is specifically a means of increasing phonological contrast. By examining both phonetic variability and phonological behavior we can determine which features are contrastive and which are redundant, as well as which redundant features are being used as phonetic enhancements (e.g. backness being used as an enhancement of [round] in English /u/). The contrast and enhancement approach proposed by Hall (2011) provides the framework needed to order distinctive features and predict which features are likely to be used as enhancements. As discussed in this chapter, the relevant distinctive features that serve to distinguish sonorants from obstruents and stops from fricatives are [+/–son] and [+/–cont], while the relevant laryngeal features are [spr gl] and [voice]. Establishing the phonological contrastivity and relative ordering of these features, as well as the presence and extent of phonetic enhancement, is the focus of the remainder of this dissertation.

Chapter 3: Norwegian

3.1. Overview

As mentioned in Chapter 1, Norwegian is reported to exhibit an unusual phonological pattern, where the FORTIS obstruents are said to not all share the same laryngeal specification: /p, t, k, f/ all induce sonorant devoicing, but /s/ does not, and /s/ also is limited in the domains where it can induce regressive devoicing assimilation. Kristoffersen argues that all Norwegian FORTIS obstruents are specified for [–voice], but also that all FORTIS obstruents except for /s/ are specified for [asp], which is the feature responsible for sonorant devoicing, and that the unique behavior of /s/ among FORTIS obstruents can be attributed in part to its lack of a voiced counterpart /z/ (2000:74-87). The aim of this chapter is to compare Norwegian LENIS and FORTIS obstruents to determine which laryngeal feature is phonologically contrastive, but also to investigate whether there are any differences in the laryngeal specification of FORTIS obstruents in particular. The results of the phonetic experiments indicate that the FORTIS obstruents, including /s/, are phonologically specified for [spr gl], while the LENIS obstruents are laryngeally unspecified, supporting a privative analysis based on laryngeal realism. It is also shown that the contrast and enhancement model can account for the phonetic and phonological behavior of Norwegian obstruents.

This chapter begins by expanding on the diachronic and synchronic background laid out in Chapter 1, examines modern Norwegian phonology, provides experimental phonetic data from a dialect of modern Norwegian, and applies the theoretical framework laid out in Chapter 2 to the results of the experiments. The experimental data were collected from speakers of the Oslo dialect, so the background material below focuses mainly on this particular variety. Norway is rich in dialectal diversity – some of which is outlined below – so a thorough diachronic and synchronic examination of all Norwegian dialects, or even the major dialect areas, would be untenable.[27]

3.2. Diachronic background

As outlined in Section 1.2.5, NGmc singleton stops (*p, *t, *k; *b, *d, *g) exhibited a two-way laryngeal contrast, mainly in word-initial position only due to postvocalic spirantization of the lenis stops (*b→*ƀ, *d→*ð, *g→*ǥ), and the spirantized allophones became voiceless word-finally or when adjacent to a voiceless obstruent (*ƀ→*f, *ð→*þ, *ǥ→*x/h), although a post-sonorant contrast (*ld/*lt, *mb/*mp, *nd/*nt, *ng/*nk) remained for a time (Haugen 1982:61). NGmc fricatives *f and *þ were voiceless word-initially, voiced word-medially between phonetically voiced segments (vowels and sonorants), and voiceless word-finally or when adjacent to another voiceless obstruent. PGmc *h was retained word-initially only, including before sonorants; elsewhere it was either lost or assimilated, and it was eventually only retained word-initially before vowels (except in Icelandic, where it has also been retained before sonorants). Recall also that PGmc *z was rhotacized and merged with *r, thereby eliminating any laryngeal contrast with *s. In other words, there was no laryngeal contrast in NGmc fricatives; *f and *þ had voiced allophones, but allophones are by definition not contrastive. In later stages, NGmc *w became *v* which gave rise to a laryngeal contrast between *f* and *v*. (See Schulte 2002a,b; Riad 2002; Sandøy 2005; Haugen 1982:57-62 for further details.)

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[27] For more on Norwegian dialects, see, for example, Akselberg (2005), Hanssen (2010), Jahr (1990), Nes (2005), Papazian & Helleland (2005), Sandøy (1992, 1996), Sjekkeland (1997), and Vigeland (1995).

Subsequent sound changes (part of, but not necessarily unique to, the history of Norwegian) affected the lenis obstruents in particular. They include the merger of the spirantized allophone *ƀ with spirantized *w (and presumably also the voiced allophone of *f) > /v/, written *v* word-initially and *f* elsewhere (Haugen 1982:63-64). Additionally, weakly stressed *k, *t, and *þ became voiced (and spirantized), affecting grammatical words in particular (*ek* > *eg* [ɣ] 'I', *vit* > *við* 'we dual'; see Haugen 1982:64). One consequence of this is that a word-initial *þ*/*ð* contrast developed: Old Norse (ON) *þu* > *ðu* 'you sg.' vs. *þing* 'assembly'.[28, 29] However, shortly after this change, *þ* and *ð* (whether the voiced allophone of *þ or the spirantized allophone of *d) became stops, except in Icelandic, merging with *t* and *d* in all other NGmc languages (Haugen 1982:66; Sjekkeland 1997:126-127). Additionally, in many cases *d*/*ð* was lost postvocalically; where <d> has been retained in Norwegian orthography in this position, it is rarely pronounced (Haugen 1982:66). Another change involved the assimilation of clusters, including sonorant-lenis stop clusters becoming geminate sonorants: *ld* > *ll*, *mb* > *mm*, *nd* > *nn*, *ŋg* > *ŋŋ* (Haugen 1982:64; Sjekkeland 1997:117-122), although Schulte (2005:1085) states that this is more characteristic of South-East Norwegian than West Norwegian.[30] Finally, although Haugen does not explicitly discuss this change, his consonant charts show that for Norwegian – both Nynorsk (1982:76) and Bokmål (1982:84) – and Swedish (1982:78), *g loses its spirantized allophone (unless it has become palatalized; see below) and is realized as a stop /g/ (similar to *ð* > *d* above,

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[28] Compare English *thou* [ð] vs. *thing* [θ], which reflects a similar sound change.

[29] See also Minkova (2013) for similar developments in English fricatives.

[30] These assimilations are sometimes reflected in the orthography (*lam* 'lamb', *lammet* 'the lamb'), sometimes not (*land* 'land', *landet* 'the land'); but even if the historical spelling is retained, the stop is almost never pronounced.

and probably part of the same sound change) unless it is lost or vocalized word-finally (Haugen 1982:68; Sjekkeland 1997:110-111; Hanssen 2010:132).[31]

The result of these changes is that in modern Norwegian, (singleton) /b/ is most commonly found in word-initial position only, its spirantized allophone having merged with spirantized *w and voiced *f to become /v/ in all other positions in native simplex words; /d/ is all but limited to word-initial position, but is sometimes pronounced in other positions (Haugen 1982:83); and /g/ has the widest distribution, with realizations in all word positions. These changes effectively eliminated most of the non-initial laryngeal contrasts for singleton stops (but not geminates), except perhaps in compound words and loanwords, and the *f-v* contrast is the only remaining fricative laryngeal contrast. Next, I discuss two other important changes that have directly affected the obstruent inventory of Norwegian (and Swedish to a similar extent), namely palatalization and retroflexion.

3.2.1. Palatalization

Palatalization affected non-labial obstruents (i.e. /d, t, g, k, s/), including /st/ and (especially, in Norwegian) /sk/ clusters, when followed by front vowels or /j/ (see Haugen 1982:65, 67; Riad 2002:906; Eliasson 2005:1122-1123). The velar stops were more affected by palatalization than the alveolar stops, especially in Norwegian and Swedish, while bare /s/ and /s/ clusters vary. Norwegian and Swedish are roughly similar, though some western Norwegian dialects have an affricate realization of palatalized stops and Swedish has a much wider range of phonemic and allophonic realizations, especially for palatalized /s/ and /s/ clusters (see Riad 2014:57-66; also

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[31] Sandøy 2005 shows the same development of *g in his consonant charts – from Proto-Nordic, Common Old Nordic, and Old East and Old West Nordic (which all show a [ɣ] allophone) to modern Norwegian and Swedish (which only show /g/) – but also without discussion or explanation.

Haugen 1982:77). In general, however, both Norwegian and Swedish have merged palatalized /d/ and /g/ to [j] and /t/ and /k/ to [ç] (alternately realized as, and merging with, [ʂ̻]/[ʃ] in some varieties; see Simonsen & Moen 2004), while palatalized /s/ and /sk/ (but generally not /st/) have become [ʂ̻] in Norwegian (Eliasson 2005:1123). Palatalization is regularly, but not always, reflected in Norwegian orthography with the insertion of *j* (cf. *gjøre* [j] 'to do' vs. *geit* [j] 'goat') where historically there was simply a front vowel:

1) ON *kær-* vs. Norw. *kjær-* [ç] 'dear, beloved' (cf. Icel. *kær-* [c])

The end result of palatalization in Norwegian is the addition of two obstruent phonemes, namely /ç/ and /ʂ̻/; though they, like /s/, lack LENIS counterparts.[32]

3.2.2. Retroflexion

According to Sandøy, a retroflex flap [ɽ], referred to in Norwegian linguistics literature as *tjukk* l ('thick *l*'), "emerged in the Central Scandinavian area during the 12th c[entury]" and "spread to eastern Norway, Trøndelag, the southern part of northern Norway, and northern and central Sweden" (2005:1857; see also Hanssen 2010:67-71 and Sjekkeland 1997:90-95). Sandøy continues to explain (2005:1859) that the retroflex articulation spread to a following alveolar consonant (/t, d, s, n, l, r/) while the retroflex flap itself was assimilated, forming a single retroflex segment, and that this occurred across word and morpheme boundaries (Sandøy's examples and transcriptions):

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[32] See Sjekkeland (1997:95-111) for more on the development and variation of palatalization in Norwegian and its dialects.

2)	gul + t	[gʉːʈ]	‘yellow’ (neut.)
	kjøl + d	[çøɖ]	‘cold’
	tel sakte	[tɛʂakte]	‘count slowly’
	stol + n	[stʊːɳ]	‘the chair’
	mål + løs	[mɔːɭøs]	‘speechless’
	gul + rot	[gʉːɻʊt]	‘carrot’

Sandøy also states that sequences of /r/ (specifically, dialects with flapped /ɾ/) + alveolar consonant merged with the “thick *l*” clusters and acquired a retroflex articulation (see also Eliasson 2005:1123-1125, and Riad 2005:1113-1114 for the development in Swedish), thus *gult* rhymes with *surt* in some varieties:

3)	gul + t	[gʉːʈ]	‘yellow’ (neut.)
	sur + t	[sʉːʈ]	‘sour’ (neut.)

Papazian & Helleland (2005:51) state that this latter type of retroflexion, with alveolar flap /ɾ/ rather than retroflex flap /ɽ/ (or “thick *l*”), coincides for the most part with the areas that have “thick *l*”, but also that it actually has a slightly broader geographic distribution, appearing in some dialects that do not have “thick *l*”; in these dialects, *gult* ‘yellow’ (neut.) is pronounced [gʉlt], but *surt* is pronounced [sʉːʈ].

Haugen (1982:67) notes that the retroflex flap “thick *l*” [ɽ] is not considered acceptable in the Oslo dialect; however, the type of retroflexion involving /ɾ/ + alveolar consonant is acceptable in “standard” Norwegian (including Oslo). Furthermore, Hanssen (2010:130) states that *rd* clusters are generally realized as [ɾ] in Oslo speech, rather than the retroflex flap [ɽ], therefore words such as *bord* ‘table’ are [boːɾ] in Oslo but [boːɽ] elsewhere in East Norwegian (Hanssen’s examples and transcription). However, Hanssen continues to explain (2010:141-147; see also Jahr 1981) that the Oslo dialect is traditionally divided into two varieties, roughly along an east-west dimension, and that one of the differences between the two varieties is that eastern Oslo has "thick *l*" but western Oslo generally does not; thus *blå* 'blue' is [bɽoː] in eastern Oslo and [bloː] (or [bɭoː]; see Kristoffersen 2000:90 and below) in western Oslo.[33] The dialect examined in this chapter is from western Oslo, and "thick *l*" occurs only once or twice in the results below.

3.3. Modern Norwegian phonetics and phonology

Norwegian is somewhat famous for having two official written standards, *Bokmål* (lit. 'book language') and *Nynorsk* (lit. 'new Norwegian'); the former is roughly based on the historically Danish-influenced urban speech of Oslo and the latter based on rural dialects, mainly in western and central Southern Norway (Kristoffersen 2000:2-4). There is, however, no officially recognized spoken standard, and Norwegian dialects are very diverse and enjoy relatively widespread use in all levels of society and in the media. As Kristoffersen (2000:7) explains, the official policy of the *Norsk Språkråd* (Norwegian Language Council, which has since been changed to *Språkrådet*) is that there should not be an official spoken norm and that all spoken varieties should be of equal status and their use acceptable in any context. This attitude toward language has resulted in the elevated status of regional varieties of Norwegian (see also Røyneland 2009). Kristoffersen points out that this policy is not uncontroversial due to strong support for *Standard Østnorsk* (Standard East Norwegian), which he describes as the formal middle-class urban speech of southeastern Norway, with Oslo as its center, and which most closely resembles the Bokmål written standard.

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[33] See also Sandøy (1996:106-107, 110) for some studies on "thick *l*" differences in eastern and western Oslo, and Haugen (1976:274-278) for more on the origin and development of retroflexion.

The term ‘East Norwegian’ itself deserves some clarification. According to Papazian & Helleland (2005:83-84, 134-135), the main division of Norwegian dialects is between East and West Norwegian; East Norwegian consists of *østnorsk* (lit. ‘east Norwegian’, alternatively *østlandsk* lit. ‘east-landic’; spoken in roughly the eastern half of Southern Norway)[34] and *trøndersk* (spoken in Trøndelag, just north of the *østnorsk*-speaking area), while West Norwegian consists of *vestnorsk* (lit. ‘west Norwegian’), which includes both *sørlandsk* (lit. ‘southern-landic’, spoken at the southern tip of Norway) and *vestlandsk* (lit. ‘west-landic’, spoken along the southwestern coast of Norway, directly west of *østnorsk*), and *nordnorsk* (lit. ‘north Norwegian’, spoken to the north of Trøndelag).

Several criteria are used in making the division between East and West Norwegian, including the *jamvektregel*, the tonal accent system, and “thick *l*” (as discussed above). The *jamvektregel*, or ‘vowel balance rule’ (lit. ‘equal-weight rule’, typically referred to simply as ‘vowel balance’ in English), refers to the development of ON disyllabic words, especially verb infinitives and weak feminine nouns. Specifically, the original ON vowel in the second, unstressed syllable was either retained, reduced, or lost. There are various outcomes in West Norwegian (see Papazian & Helleland 2005:45), but in East Norwegian, the retention of the final vowel, and whether it is full or reduced, depends on the weight of the stem in ON, and this is the *jamvekt*, or ‘equal (vowel) weight’, rule. If the stem was light in ON (a short vowel followed by a singleton consonant, e.g. *vera* ‘to be’), then the final vowel often resisted reduction and apocope in East Norwegian because the vowel of the second syllable is thought to have had equal, or nearly equal, weight.

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[34] Papazian & Helleland (2005:83) state that the East-West dialect border runs along the *Langfjella* mountain range, which divides Southern Norway approximately from Vest-Telemark in the south to Gudbrandsdal in the north.

(See Papazian & Helleland 2005:44-47, Hanssen 2010:84-89, and Sjekkeland (1997:67-80) for more on the *jamvekt* rule.)

The second criterion, the tonal accent system, is found in all but a few Norwegian dialects, and corresponding tonal contrast systems are found in Swedish and Danish (Kristoffersen 2000:234). There is a large body of literature on this topic[35] and the historical development is complicated,[36] but Kristoffersen states that "[t]he most common explanation relates it to a supposed tonal difference between mono- and polysyllabic words in Old Norse. Since the two melodies pertained to two different domains defined by number of syllables, they were predictable and non-contrastive" (2000:235). The tonal melodies associated with words that were mono- or polysyllabic in ON are commonly referred to as 'accent 1' and 'accent 2', respectively. Subsequent developments, such as the syllabification of certain non-syllabic sonorants in ON and the suffixation of definite articles, changed a large number of monosyllabic words into polysyllabic words; however, these formerly monosyllabic words retained their accent 1 melody even though they had become polysyllabic, thereby introducing a tonal contrast into the language (Kristoffersen 2000:235-236):

4) disyllabic ON *opinn* > Norwegian *åpen* 'open' (accent 2)
monosyllabic ON *vápn* > Norwegian *våpen* 'weapon' (accent 1)

Accent 1 and accent 2 have different melodies in different dialect groupings, and the dialect groupings correspond to a large degree with East and West Norwegian. For example, accent 1 is generally realized with a low rising tone in East Norwegian dialects and with a high falling tone

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[35] See especially Fintoft (1970) and Wetterlin (2010); see also Kristoffersen (2000:233-273) for further references and analysis.

[36] See Haugen (1976:281-285; 1982:22-24) and Riad (1998) for a historical overview.

in West Norwegian dialects (accent 2 shows more variation; see Kristoffersen 2000:236-238 for details).

The distribution of "thick *l*" corresponds for the most part with East Norwegian, but is absent in part of the East Norwegian area and present in parts of West Norwegian (Hanssen 2010:68-69, Papazian & Helleland 2005:83-84). Therefore the division into East and West Norwegian is not entirely clear-cut, and Papazian & Helleland (2005:84) note several other problems with this two-way division, opting instead for a four-way division into *vestnorsk* (including *sørlandsk*), *østnorsk*, *nordnorsk*, and *trøndersk*, based on both linguistic criteria and county boundaries.[37] I adopt their larger groupings here, with four main divisions: West Norwegian, East Norwegian, Trøndelag Norwegian, and North Norwegian, as depicted in Figure 3.1. (See also Hanssen 2010:117-194, Vigeland 1995:21-42, and Sandøy 1996:146-244 for more on the major dialect divisions in Norwegian.)

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[37] This four-way division is also common in much of the Norwegian dialect literature, e.g. Jahr (1990), Hanssen (2010); but it seems that even those who use a two-way division invariably recognize additional subgroupings.

Figure 3.1 Norwegian dialect areas (map source: https://www.ntnu.edu/now/intro/background-norwegian)

Kristoffersen (2000) focuses on a variety of Norwegian he calls “Urban East Norwegian” (UEN). He explains that his choice to cover UEN is a reaction to previous work which focused on Standard East Norwegian, but since there is no spoken standard, “it is difficult to delimit [Standard East Norwegian] in a precise and uncontroversial way from other urban varieties of the same region,” so he decides to cover “urban East Norwegian in general” (2000:8). After giving some history of Standard East Norwegian, which he describes as originating from the heavily Danish-influenced sociolect of the educated class in Oslo, he further explains that, in order to account for other East Norwegian dialects with less historical influence from Danish, UEN is essentially a cover term for any urban dialect of East Norwegian. While there is bound to be some variation between these dialects, we can assume Kristoffersen’s analysis of UEN to be valid for any urban East Norwegian dialect, including the dialect examined in this chapter. Kristoffersen gives the consonant inventory of UEN below (2000:22):

	Bilabial/ labiodental	Dental/ alveolar	Retroflex	Palatal	Velar	Laryngeal
Stops	p, b	t, d	ʈ, ɖ		k, g	
Nasals	m	n	ɳ		ŋ	
Fricatives	f	s	ʂ	ç		h
Liquids		ɾ, l	ɽ, ɭ			
Approximants	ʋ, w			j		

Table 3.1 Urban East Norwegian consonant inventory

Table 3.1 shows the consonant inventory of modern UEN, and many of these segments are inherited from the original NGmc consonant inventory, but with some additional segments due to palatalization and retroflexion, as explained above. Some remarks are in order. Kristoffersen (2000:22) explains that the dental/alveolar series is laminal while the retroflex series is apical, also noting that some researchers disagree whether the retroflex stops are post-alveolar or alveolar, or that they vary between the two. The precise places of articulation do not play a major role in the present discussion, so I will simply use the terms ‘alveolar’ and ‘retroflex’.

Kristoffersen (2000:88) argues that there is a difference between non-derived and derived retroflex segments: in non-derived environments, i.e. in simplex words, the retroflex is considered underlying and phonemic whereas in derived environments, i.e. across morpheme or word boundaries, it is governed by rule (which he calls the Retroflex Rule). The implication here is that because the retroflex series was historically formed by /r/ (or /ɽ/) followed by an unmarked alveolar consonant /t, d, s, n, l, r/, the conditions for the phonemic, non-derived retroflex series only existed word-medially or word-finally, because such clusters never existed word-initially (e.g. **#rt-*). As Kristoffersen states, “[t]he distribution is to a considerable extent predictable” (2000:88); as the examples in 3.2.2. illustrate, derived environments can exist in any word position, but non-derived retroflex segments do not occur word-initially. The only exception here is /ɭ/ (which may affect /sɭ/ clusters, becoming [ʂɭ]; see below); Kristoffersen (2000:24-25) cites several authors (Vanvik 1972; Papazian 1977; Jahr 1981, 1988) who have reported that the unmarked alveolar lateral /l/ is increasingly being replaced by retroflex /ɭ/ as the default lateral, meaning that it can appear word-initially as a phoneme. Furthermore, Hanssen (2010:71) states that “laminal *l*” can trigger retroflexion in unstressed syllables, and that this is common in Oslo speech; this may be related to its increasing retroflex/apical articulation.[38]

Kristoffersen (2000:23) notes that there is some disagreement as to whether /ʂ/ is better represented as postalveolar [ʃ] or retroflex [ʂ], or whether there is a phonetic difference between palatalized (historical) and retroflex (synchronic) *s*.[39] Kristoffersen transcribes it as [ʂ], “assuming that the sound in contemporary UEN is an apical, irrespective of phonological environment and historical origin…but lacking a thorough investigation of the articulatory properties of this sound, I do not mean to imply that it will be a retroflex sound for all speakers and in all environments” (2000:23); this is the view I adopt here.[40]

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[38] See Kristoffersen (2000:96-100), Bradley (2002), and Stausland Johnsen (2012a, 2012b, 2012c) for further discussion of retroflexion in Norwegian.

[39] He cites Larsen (1907:41), who says that at the turn of the last century, there was a distinction between the two.

[40] This contrasts with Hanssen (2010:54), who states that [ʃ] is found in most of the country, but it is either [ʂ] or [sj] in *vestnorsk*.

Additionally, as previously discussed, /ʂ/ is either the (historical) result of palatalized *s* (*sjø* [ʂøː] 'sea') or *sk* (*skje* [ʂeː] 'spoon'), or the result of retroflexion when preceded by /ɾ/ (*vers* [ʋæʂ] 'verse') or when adjacent to another retroflex segment (*slå* [ʂɭoː] 'to hit'; *bortsett (fra)* [bʊʈʂɛtː] 'aside (from), except'). Though there is no doubt as to the status of /ʂ/ as a phoneme synchronically, it can also be analyzed as allophonic [ʂ] in derived environments, as proposed by Kristoffersen (2000:88). To take the example of *bortsett* [bʊʈʂɛtː] 'except', *bort* [bʊʈ] 'away' and *sett* [sɛtː] 'seen' exist as independent lexical items; also across word boundaries, *for* [fɔɾ] 'too' and *sent* [sent] 'late' are together *for sent* [fɔʂent] 'too late'; in both of these cases, underlying /s/ is realized as [ʂ] when preceded by a retroflex (or retroflex-triggering) segment. Word-initial minimal pairs can be found for /s/ and /ʂ/,[41] but the latter is either historically derived from palatalized *s* or *sk* (but synchronically phonemic) or is found in an *sl* cluster:

5) /s/ ~ /ʂ/: *sel* [seːl] 'seal' *sjel* [ʂeːl] 'soul' *skje* [ʂeː] 'spoon'
/s/ ~ [ʂɭ]: *sutte* [sʉtːə] 'to suck' *slutte* [ʂɭʉtːə] 'to end'

Note also that other Norwegian (non-UEN) dialects have either [sl] or [ʂɭ], but these sounds never occur contrastively within the same dialect. According to Hanssen (2010:71), the realization of *sl* as [ʂɭ] (or [ʃɭ] in his transcription) is common in the eastern half of East Norwegian,[42] Trøndelag Norwegian, and North Norwegian. However, aside from [ʂɭ], any instances of (non-derived) word-initial [ʂ] are the result of palatalization, not retroflexion. Kristoffersen says that "[i]n vernacular varieties of UEN there has for a long time been a complementary distribution between [s] and [ʂ], such that the latter occurs before a lateral" and that the realization of *sl* as [ʂɭ] is "near obligatory" in word-initial position, but in other positions,

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[41] Kristoffersen (p.c.) points out that <sj> is also used to represent postalveolar /ʃ/ in loanwords, e.g. *sjef* 'boss' < French *chef*; these are clearly not cases of palatalization of earlier /sj/.

[42] East Norwegian is commonly further subdivided into *fjellbygdmål* ('mountain community speech') in the more mountainous western half and *flatbygdmål* ('flat-land community speech') in the flatter eastern half; see Hanssen (2010:125-155).

it varies according to sociolinguistic and structural factors (2000:102-104). Thus in the case of [ʂɭ], the [ʂ] is allophonic, conditioned by the following /l/ (or /ɭ/); in other /s/ clusters (*sn*, *sm*, *sv*, *st*, *sp*), the realization is always [s] (unless preceded by a retroflex-conditioning segment). As mentioned above, the unmarked realization of /l/ is changing from plain alveolar (or laminal) [l] to retroflex (or apical) [ɭ], but Kristoffersen does not mention that the realization of *sl* as [ʂɭ] has any connection to this development. However, Jahr (1981, 1988) argues that the [ʂɭ] pronunciation seems to have coincided with the transition from [l] to [ɭ], specifically that [ʂɭ] is the result of regressive assimilation from retroflex [ɭ]. In any case, [ʂɭ] in word-initial position is essentially universal for UEN, including Oslo.

There are a few final points regarding certain segments in Table 3.1. The first concerns the retroflex flap [ɽ], whose "phonemic status is precarious" in UEN, according to Kristoffersen, because "[i]n most roots where it may occur, it can alternate with [ɾ] in words where Old Norse had /rð/ and with [l] where Old Norse had /l/" with only a few words where [ɽ] is required (2000:24). Additionally, as mentioned above, [ɽ] is more commonly heard in eastern Oslo than in western Oslo (see especially Jahr 1981:88-92). A second point concerns /h/, which has been lost except in word-initial, prevocalic position in Norwegian, as noted in Section 3.2. As Kristoffersen (2000:24) notes, "phonologically [/h/] does not enter into a natural class relationship with fricatives, nor with approximants", so "[i]ts classification here as a fricative is simply a matter of convenience." Thus /h/ is of little relevance in the remaining discussion.

The final point concerns the approximant /ʋ/.[43] Kristoffersen (2000:39) notes that it patterns as both a sonorant and a fricative in its phonotactic distribution. It can occur before sonorants in codas (*hevn* [hɛʋn] ‘revenge’, *trevl* [tʰr̥ɛʋɭ] ‘shred’) and after obstruents in onsets (*tverr* [tʰfær] ‘sullen’, *tvile* [tʰfiːlə] ‘to doubt’), but also before sonorants in the obstruent slot in onsets (*vrøvl* [ʋrœʋɭ] ‘nonsense’). Kristoffersen continues to explain that according to the Sonority Sequencing Principle (Clements 1990), onsets should rise in sonority toward the nucleus and codas should fall in sonority away from the nucleus, and the order of sonority in speech sounds is as follows: vowels > glides > liquids > nasals > obstruents. If this is the case, then /ʋ/ ought to be more sonorous than liquids or nasals if it precedes them in codas, in which case it could be classified as an approximant. On the other hand, if it can precede a liquid in an onset, as in *vrøvl*, it ought to be less sonorous, in which case it could be classified as an obstruent. Kristoffersen also mentions (2000:25) that phonetically, /ʋ/ normally lacks the typical aperiodic noise of a fricative in articulation. However, /ʋ/ also devoices to /f/ in voicing assimilations (*stiv* [stiːʋ] ‘stiff’ masc./fem. vs. *stivt* [stiːftʰ] ‘stiff’ neut.).

As mentioned in Chapter 2, /v/ (or /ʋ/) is often problematic, in various languages, because it patterns as both an obstruent and a sonorant. As discussed in Sections 2.1 and 2.4, part of this may be attributable to the fact that labials have the largest oral cavity, which makes it easier to maintain voicing, and part of it may be due the conflict between the higher airflow requirements for frication (requiring a more open glottis) and the closely approximated vocal folds required for voicing; in this case, frication may be sacrificed for more prominent voicing, giving /v/ more of the qualities of an approximant /ʋ/. Recall also that Norwegian /ʋ/ has three sources historically:

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[43] Kristoffersen also lists /w/ as an approximant, but its distribution is limited to the second element in diphthongs, e.g. *sau* [sæw] ‘sheep’ (2000:11, 14, 17, 19) or as a glide between vowels, e.g. *duell* [dʉ.wɛl] ‘duel’ (2000:20).

non-initial *f in voiced environments, non-initial *b in voiced environments, and *w. Thus in addition to the approximant properties and word positions it inherited from *w, /ʋ/ also inherited some obstruent properties and word positions (though word-initial *vr* is inherited from PGmc *wr, so it could be argued that that sequence is still approximant-sonorant). In light of these peculiarities, /ʋ/ will be treated as both an obstruent and a sonorant in the discussion that follows.

3.3.1. Phonotactics

Since one focus of this dissertation is sonorant devoicing, we are interested to know which obstruents combine with which sonorants from Table 3.1. Table 3.2, adapted from Kristoffersen (2000:50), outlines the basic phonotactic structure of UEN (and could easily be adapted for many other Norwegian dialects), showing which obstruents can combine with which sonorants word-initially:

	/m/	**/n/**	**/l/**	**/r/**	**/j/**	**/ʋ/**
/p/			/pl-/	/pr-/	/pj-/	
/b/			/bl-/	/br-/	/bj-/	
/t/				/tr-/	(/ç-/)	/tʋ-/
/d/				/dr-/	(/j-/)	/dʋ-/
/k/		/kn-/	/kl-/	/kr-/	(/ç-/)	/kʋ-/
/g/		/gn-/	/gl-/	/gr-/	(/j-/)	
/f/		/fn-/	/fl-/	/fr-/	/fj-/	
/ʋ/				/ʋr-/		
/s/	/sm-/	/sn-/	/sl-/ ([ʂɭ-])		(/ʂ-/)	/sʋ-/

Table 3.2 Possible word-initial consonant clusters in Norwegian[44]

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[44] Complex clusters with /s/ are also possible: /spl-/, /spr-/, /spj-/; /str-/, /stj-/; and /skl-/, /skr-/, /skʋ-/; but they are outside the scope of this dissertation since sonorant devoicing does not occur in these clusters

The main things to reiterate here are the historical developments resulting from palatalization of certain *Cj* combinations, namely that *kj* and *tj* became a palatal fricative /ç/, *gj* and *dj* became a palatal glide /j/, and *sj* became a palatal (retroflex) sibilant /ʂ/. Since these palatal segments are the result of a phonological process that applied to obstruent-/j/ clusters historically, they are not found in obstruent-sonorant clusters today (i.e. clusters such as *[çl-], *[çr-] do not occur), and as such they are irrelevant to a discussion of sonorant devoicing. In addition, the sequence /sl/ surfaces as [ʂɭ] in UEN, but [ʂ] does not occur in other clusters (e.g. *[ʂm], *[ʂr]) so its occurrence before /l/ is predictable. Finally, note that [ʂ] is the only retroflex obstruent that combines with sonorants word-initially; /ʈ, ɖ/ do not. Therefore, the following represents the basic word-initial phoneme inventory of Norwegian obstruents, as seen in the far left column in Table 3.2 above, that will be treated in this chapter:

FORTIS	p	t	k	f	s
LENIS	b	d	g	ʋ	

Table 3.3 Norwegian (UEN) obstruent inventory, minus palatal and retroflex segments

3.3.2. Norwegian laryngeal phonology

Regarding these obstruents, Kristoffersen explains the phonetic difference between /b, d, g/ and /p, t, k/ in terms of laryngeal activity: /b, d, g/ are voiced in postvocalic position, whereas /p, t, k/ are voiceless. However, at the beginning of a word or stressed syllable, "the two series are distinguished phonetically not primarily by voice, but by /p, t, k/ being aspirated and /b, d, g/ being unaspirated, voiceless or only partially voiced," and that the contrast is neutralized when

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(Kristoffersen 2000:76). See, for example, Iverson & Salmons (1995) for further discussion of (the lack of) sonorant devoicing in these types of clusters in related languages.

/p, t, k/ follow /s/ (in other words, word-initial /sp-, st-, sk-/ lack aspiration) (2000:22). He further states that this is true for UEN "as well as all other varieties of Norwegian" (2000:74). Recall also from Section 1.3.2 that Halvorsen's (1998) study of the Bergen, Trøndelag, and East Norwegian dialects finds an average of approximately 60-65 ms of aspiration after /p, t, k/, while the degree of voicing lead or lag on /b, d, g/ is highly variable, even within the same dialect. Based on the discussion of privativity and laryngeal realism in Chapter 2, this suggests that phonologically, Norwegian /b, d, g/ are laryngeally unspecified (since voicing is optional and highly variable) but /p, t, k/ are specified for [spr gl] (since they are regularly and consistently aspirated).

Further evidence for a privative [spr gl] analysis is derived from Kristoffersen's discussion of progressive and regressive devoicing below (2000:72-87). His analysis specifically compares the [voice] approach of Lombardi (1991, 1995) with the [spr gl] approach of Iverson & Salmons (1995), i.e. laryngeal realism, as outlined in Section 2.6.

3.3.2.1. Progressive devoicing

Kristoffersen states that only "sequences where a non-nasal sonorant (including /ʋ/) follows a voiceless stop or /f/" will exhibit full or partial sonorant devoicing (2000:75), arguing elsewhere that /s/ fails to induce sonorant devoicing because it lacks a laryngeal specification due to the absence of a voiced counterpart /z/ in the inventory (2000:82). The following are some of the examples he provides (2000:76):

6) /pris/ [p^{h}r̥iːs] ‘price’

/trakt/ [t^{h}r̥ɑkt] ‘funnel’

/kreʋe/ [k^{h}r̥eː.ʋə] ‘to demand’

/fri/ [fr̥iː] ‘free’

/tʋile/ [t^{h}fiːlə] ‘to doubt’

BUT: /slo/ [s̩ɭoː] ‘to beat’ (with no devoicing of /l/)

/sʋi/ [sʋiː] ‘to burn’ (with no devoicing of /ʋ/)

Thus in Kristoffersen’s analysis, the word-initial clusters /kn-/, /fn-/, /sm-/, /sn-/, /sl-/, and /sʋ-/, which are legitimate combinations in Norwegian (as shown in Table 3.2 above), will not exhibit sonorant devoicing because they either a) contain a nasal sonorant or b) start with /s/. It is unclear why nasal sonorants would be excluded while liquids are not, especially since voicing is redundant in both sets. However, with regard to /s/, Kristoffersen specifies that “devoicing does not take place after /s/” (2000:81).

In summary, Kristoffersen’s account of progressive sonorant devoicing in UEN is that it takes place after /p, t, k, f/ but not /s/ and does not affect nasals. As noted above, Kristoffersen describes /p, t, k/ as being aspirated and /b, d, g/ as being only passively or optionally voiced, so both aspiration and sonorant devoicing occur, as predicted by Iverson & Salmons (1995) for an ‘aspirating’ language.

3.3.2.2. Regressive Devoicing

Kristoffersen (2000:76-79) notes that regressive devoicing assimilation only takes place before suffixes starting in (or consisting of) /t, s/ (there are no suffixes starting in /p, k, f/) with the notable exception of the possessive clitic /s/, as he illustrates with the following examples where /s/ does not induce devoicing in *livs* or *skogs* (2000:77; Kristoffersen's transcription):

7) *et langt livs erfaring* [ɛt. lɑŋt. liːʋ.s æ.fɑː.ɾiŋ] 'a long life's experience'

en skogs avkastning [ɛn. skuːg.s ɑʋ.kɑst.niŋ] 'a forest's yield'

However, since clitics and affixes behave differently morphologically (and possibly also prosodically), the failure of clitic /s/ to induce regressive devoicing might not be an exception after all, but could simply be explained by the fact that it is a clitic as opposed to an affix.[45]

Kristoffersen notes that while the possessive clitic /s/ does not seem to induce regressive devoicing, several affixes beginning in (or consisting of) /s/ do; namely the old genitive case marker /-s/, the linking phoneme /-s-/ in compounds, the nominalizing suffix *-sel*, the superlative marker *-st*, and the patronymic *-sen* (2000:77-79; Kristoffersen's examples and transcription):

8)	genitive marker /-s/:[46]	*skog* [skuːg] 'woods, forest'
		dra til skogs [dɾɑː. til. skuks] 'go to the woods'
	linking phoneme /-s-/:	*liv* [liːʋ] 'life'
		livserfaring [lif.sæ.fɑː.ɾiŋ] 'experience in life'
	nominalizing suffix *-sel*:	*føde* [føː.də] 'to give birth'
		fødsel [fœt.sl̩] 'birth'
	superlative marker *-st*:	*vanlig* [ʋɑːn.li] 'common'
		vanligst [ʋɑːn.likst] 'most common'

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[45] As Kristoffersen states: "The fact that [clitic /s/] generally does not cause devoicing shows that it is not constrained by a prosodic constituent such as the PWd, it is in fact lexical" (2000:77).

[46] Kristoffersen notes two exceptions where devoicing does not take place: *sette til veggs* [sɛt.tə. til. ʋɛgs] 'drive into a corner' and *forlodds* [fɔ.ɭɔds] 'in advance' (2000:78), but the stems for both of these end in voiced geminates (*vegg* 'wall' and *forlodd* 'advance') so it's possible that the voiced geminate is blocking devoicing.

patronymic -*sen*: *Konrad* [kɔn.ɾɑd]

Konradsen [kɔn.ɾɑt.sn̩]

Additionally, the adjectival agreement suffix /-t/ causes regressive devoicing (2000:77):[47]

9) *trygg* [tɾyg] ‘safe’ + /-t/ = [tɾykt]

grov [gɾɔːʋ] ‘coarse’ + /-t/ = [gɾɔft]

Finally, regressive sonorant devoicing of /ɾ/ takes place before a voiceless, non-coronal obstruent (Kristoffersen 2000:79):[48]

10) *skarp* [skɑɾ̥p] ‘sharp’

kork [kɔɾ̥k] ‘cork’

skjerf [ʂæɾ̥f] ‘scarf’

This only occurs before non-coronal obstruents because /ɾ/ plus a coronal obstruent would result in a retroflex segment. Kristoffersen mentions in a footnote that regressive devoicing of both /l/ and /r/ takes place in other Norwegian dialects (2000:79, f.n. 21).

3.3.3. Laryngeal realism in Norwegian

In terms of laryngeal realism as discussed in Section 2.7, this description of Norwegian matches the description of a [spr gl] language, with aspiration, sonorant devoicing, and assimilation to voicelessness in clusters being the key criteria. This is also essentially the conclusion Kristoffersen reaches, the main difference being that he makes room in his solution to account for the failure of /s/ to induce sonorant devoicing (see Kristoffersen 2000:80-87 for details).

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[47] Kristoffersen notes one possible exception, namely *gløgg* 'intelligent', which inflected surfaces as [glœgt], not *[glœkt]; this was included in my regressive devoicing experiment and is consistently produced as [glœkt] for all of my Oslo speakers. Results are discussed below.

[48] Also note that all sonorants can undergo regressive devoicing in Icelandic (Árnason 2011:109-110) and Faroese (Árnason 2011:124). Helgason (1999) also provides some regressive sonorant devoicing data for a dialect of Swedish.

Note, however, that the "exceptions" listed by Kristoffersen are not cases of the opposite type of assimilation occurring, namely voicing assimilation (i.e. a voiceless segment becoming voiced), but they are only cases where devoicing assimilation does not happen to occur. Thus the evidence presented so far, including the lack of regressive devoicing in certain cases, still allows for a privative [spr gl] analysis in Norwegian since there is no evidence that [voice] is phonologically active.

3.4. Experimental data

I now turn to the experimental data, which was collected in Oslo, Norway. Because the focus is on the laryngeal specification of all obstruents, I collected data for both stops and fricatives. However, studies of laryngeal phonetics and phonology typically focus on stops due to the fact that it is fairly straightforward to measure VOT on stops, either prevoicing or voicing lag; fricatives, on the other hand, are typically unaspirated, so an alternative method is required to determine the laryngeal specification. It has been reported that FORTIS fricatives can devoice a following sonorant (Iverson & Salmons 1995:4); therefore I include measurements of sonorant devoicing, comparing LENIS stops to FORTIS stops, and then comparing FORTIS stops to FORTIS fricatives. A further comparison was made for regressive devoicing before /t/ and before /s/.

3.4.1. Methodology

Data were collected from eight subjects, five female (called F1, F2, F3, F4, and F5) and three male (called M1, M2, and M3). Subjects ranged from 25-40 years old, and all subjects were born and raised in western Oslo and had no known hearing or speaking deficiencies. Subjects were recorded using a Samson GoMic tabletop microphone, positioned approximately 18 inches from the speaker's mouth. As mentioned in Chapter 1, I used a sociophonetic approach to the recordings, so subjects were not recorded in a soundproof booth or phonetics laboratory; they were recorded either in their homes or in a similar casual setting. Results were pooled across speakers and gender (though I will comment on a few observed differences) and analyzed using Praat software (Boersma & Weenink 2015).

The subjects were asked to read a list of 110 words, twice through, with each word embedded in a carrier phrase (*kan du si _____ for meg?* 'can you say _____ for me?'), so that each word-initial target consonant appears in a voiced environment (V#CV- or V#CLV-, where L is any sonorant). Similar studies (Docherty 1992 for British English, Jessen 1998 for German) have investigated voicing and VOT in multiple environments (utterance-initial, after voiceless obstruents, word-medial or word-final); I decided here to focus on a single word-initial environment. In the absence of any voicing cues, it is difficult – if not impossible – to measure stop closure duration acoustically in utterance-initial position. In fact, there were a very few cases (fewer than 10 total) when a speaker paused briefly before uttering the target word in the carrier phrase; when this occurred, there was invariably no pulsing and the closure duration could not be determined (these cases were excluded from the results). I could have used a voiceless fricative before the stop (as in Jessen 1998), but this could have presented problems for measuring word-initial voiceless fricatives. I wanted to compare and contrast LENIS and FORTIS stops and fricatives in the same environment, so I chose post-vocalic, word-initial position for this chapter and subsequent chapters.

The 110 words in the list were based on Table 3.2, reproduced here as Table 3.4, and include both simple (bare) obstruent onsets (first vertical column) and simple sonorant onsets (first horizontal row) to provide baseline measurements, as well as complex obstruent-sonorant onsets (all of the internal boxes that are not grayed out):

	/m/	**/n/**	**/l/**	**/r/**	**/j/**	**/ʋ/**
/p/	▨	▨	/pl-/	/pr-/	/pj-/	▨
/b/	▨	▨	/bl-/	/br-/	/bj-/	▨
/t/	▨	▨	▨	/tr-/	(/ç-/)	/tʋ-/
/d/	▨	▨	▨	/dr-/	(/j-/)	/dʋ-/
/k/	▨	/kn-/	/kl-/	/kr-/	(/ç-/)	/kʋ-/
/g/	▨	/gn-/	/gl-/	/gr-/	(/j-/)	▨
/f/	▨	/fn-/	/fl-/	/fr-/	/fj-/	▨
/ʋ/	▨	▨	▨	/ʋr-/	▨	▨
/s/	/sm-/	/sn-/	/sl-/ ([ʂɭ-])	▨	(/ʂ-/)	/sʋ-/

Table 3.4 Possible word-initial obstruent-sonorant combinations in UEN

Target words were selected using Haugen's *Norwegian-English Dictionary* (1974) and in consultation with a native Norwegian speaker. Each of the bare obstruents, bare sonorants, and obstruent-sonorant combinations appeared twice in the word list, usually with stem vowels of different qualities to help eliminate speaker fatigue. That makes nine obstruents, plus six sonorants, plus 26 obstruent-sonorant combinations, times two, for a total of 82 target words in the word list. As noted above, this experiment is limited to comparing word-initial obstruents in the onset of a stressed syllable of a disyllabic word. To control for vowel length and tonal accent, each of these words is accent 2, and, whenever possible, with a short stressed vowel followed by a voiceless geminate consonant or consonant cluster. However, this was not always possible, because some of the obstruent-sonorant combinations are quite rare (there are only a few instances of *fn-* in Haugen's dictionary). A full list of target words is provided in Appendix A.

The remaining 28 words, approximately 20% of the total, were distractors, of varying lengths and pitch accents, again to reduce speaker fatigue. However, many of these distractors served a purpose; they contained regressive devoicing environments that were subsequently measured. With 110 words in the list, and each of the eight speakers reading the list twice, that makes a total of 1,760 tokens, 1,312 of which were target tokens (non-distractors). Tokens were discarded if there was background noise or the tokens were otherwise unanalyzable, or if they were clear outliers.

For each of the 1,312 target tokens that were retained and analyzed, the following measurements were made (this also applies to Dutch and Swiss German in the following chapters):[49]

For a word-initial stop:

- Closure duration: the duration of stop closure, measured from the end of the preceding vowel to the stop release
- VoffT (voice offset time, voicing tail): the duration of glottal pulsing that continues into the stop closure from the preceding vowel
- % pulsing: the ratio of VoffT to closure duration
- VOT: from stop release to the onset of voicing

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[49] See Rodgers (2014) for an examination of laryngeal contrasts with a focus on energy measurements as opposed to VOT or closure duration.

For a word-initial fricative:

- Fricative duration
- VoffT (voicing tail)
- % pulsing

For a sonorant:

- Sonorant duration
- Sonorant devoicing duration
- % sonorant voicing: the ratio of the voiced portion of the sonorant to the total sonorant duration

For sonorant devoicing, the devoiced portion of a sonorant is typically characterized by a drop in energy compared to the preceding stop aspiration or fricative noise, and this drop in energy is used to mark sonorant devoicing duration. This is particularly visible in devoiced nasals, but not always with devoiced /l/, though a more noisy devoiced /l/ typically also exhibits energy at different frequencies than aspiration or frication noise. These differences aided in marking sonorant devoicing duration.

ANOVAs were calculated for many measures, with the alpha value for *p* set to .05 throughout.

3.4.2. Schwa epenthesis

Several problems arose in certain data sets that will be discussed below, but one rather pervasive issue is schwa epenthesis, which occurs quite frequently between obstruents and a following sonorant. Schwa epenthesis is most visible in waveforms after LENIS stops, as might be expected, since schwa epenthesis after FORTIS stops would be masked by aspiration. Results for LENIS stops are provided below, with the number of tokens with schwa (and % out of a possible 32 tokens) and the mean duration of the epenthetic schwa:

		/ɾ/	/n/	/ʋ/	/l/
/b/	# schwa	31 (96.88%)			3 (9.38%)
	mean dur.	29 ms			27 ms
/d/	# schwa	32 (100%)		18 (71.88%)	
	mean dur.	32 ms		31 ms	
/g/	# schwa	30 (93.75%)	18 (71.88%)		8 (25%)
	mean dur.	37 ms	28 ms		32 ms

Table 3.5 Schwa epenthesis after LENIS stops, with the number of tokens with epenthetic schwa (out of 32) and the mean duration

Notice that nearly all of the Cr- tokens exhibit schwa epenthesis, followed by 18 each for /gn-/ and /dʋ-/, while only a few of the Cl- tokens show schwa epenthesis (a few more for /gl-/ than /bl-/). The high number of Cr- tokens with schwa epenthesis is explained by the fact that the rhotic is the alveolar tap /ɾ/. What is surprising is the high number of /gn-/ and /dʋ-/ tokens with schwa epenthesis, with well over half of them exhibiting this trait. It is interesting to note that speaker F1 produced all three of the /bl-/ tokens and four of the eight /gl-/ tokens with schwa epenthesis; speakers F2 and F4 each produced one token of /gl-/ with schwa epenthesis, and speaker M1 produced two. Even though there are several Cl- tokens with schwa epenthesis, only one was realized as a retroflex flap [gɽ-] (by speaker F4); recall that this sound is generally avoided in western Oslo speech. For /dʋ-/, only one speaker, F5, did not produce any with schwa epenthesis; two speakers, M1 and M2, produced all four of their /dʋ-/ tokens with schwa epenthesis.

We now compare these results to schwa epenthesis after FORTIS stops, which in all cases was measured after the cessation of aspiration:

		/ɾ/	/n/	/ʋ/	/l/
/p/	# schwa	21 (65.63%)			1 (3.13%)
	mean dur.	20 ms			28 ms
/t/	# schwa	22 (68.75%)		4 (12.5%)	
	mean dur.	25 ms		16 ms	
/k/	# schwa	22 (68.75%)	-		-
	mean dur.	23 ms	-		-

Table 3.6 Schwa epenthesis after FORTIS stops, with the number of tokens with epenthetic schwa (out of 32) and the mean duration

Once again, we see a high number of Cr- tokens with schwa epenthesis, also connected to the alveolar tap /ɾ/. However, there is no schwa epenthesis in any /kn-/ or /kl-/ tokens, only four /tʋ-/ tokens show schwa epenthesis (one from speaker M2, two from M3, and one from F5), and the single token of /pl-/ with schwa epenthesis is due to a retroflex flap articulation [pɽ-] (incidentally, this token was from the same speaker (F4) as the [gɽ-] token above).

Finally, we also see schwa epenthesis after fricatives; here, I show both LENIS and FORTIS fricatives, but only those fricative-sonorant clusters that exhibit schwa epenthesis:

		/ɾ/	/ʋ/
/ʋ/	# schwa	32 (100%)	
	mean dur.	32 ms	
/f/	# schwa	29 (90.63%)	
	mean dur.	22 ms	
/s/	# schwa		11 (34.38%)
	mean dur.		19 ms

Table 3.7 Schwa epenthesis after fricatives, with the number of tokens with epenthetic schwa (out of 32) and the mean duration

Unsurprisingly, nearly every /fɾ-/ token and all /ʋɾ-/ tokens show schwa epenthesis. A moderate number of /sʋ-/ tokens have schwa epenthesis (speaker F4 produced all of hers with epenthesis; speakers F2, F3, and M2 did not have any), somewhere between that of /tʋ-/ and that of /dʋ-/.

The relatively large number of tokens with schwa epenthesis can be attributed to a phenomenon Endresen calls *open overgang* ‘open transition’, which he says is typical in Norwegian, as opposed to *tett overgang* ‘tight transition’, which he says is more common in English (1989:97-100). The transition he is referring to here is the transition from one consonant to another, and he specifically mentions the possible East Norwegian pronunciation of *blå* ‘blue’ as [bɛl]å with an epenthetic vowel (his transcription; 1989:99). This is perhaps the reason why we see so many tokens with schwa epenthesis, and not just before /ɾ/ as we might expect, but also before /ʋ/, /n/, and /l/. In spite of this, the results below still show a statistically significant difference in sonorant devoicing after LENIS vs. FORTIS stops.[50]

3.5. Results

3.5.1. Stops

3.5.1.1. Stop closure duration

First, we compare mean closure duration for simple and complex onsets for stops (32 tokens per category), paired by place of articulation:

		bare	/j/	/l/	/m/	/n/	/ɾ/	/ʋ/
b		/b-/	/bj-/	/bl-/			/bɾ-/	
	mean	126.93	109.15	119.14			110.52	
	st. dev.	28.00	21.81	23.47			22.41	
p		/p-/	/pj-/	/pl-/			/pɾ-/	
	mean	119.88	120.37	116.02			120.74	
	st. dev.	29.27	25.22	26.70			24.30	
d		/d-/					/dɾ-/	/dʋ-/
	mean	118.22					101.05	103.26
	st. dev.	26.83					27.79	25.71
t		/t-/					/tɾ-/	/tʋ-/
	mean	115.34					100.00	100.99
	st. dev.	27.57					27.51	22.77
g		/g-/		/gl-/		/gn-/	/gɾ-/	
	mean	115.43		101.97		87.49	95.31	
	st. dev.	23.41		25.17		27.52	24.06	
k		/k-/		/kl-/		/kn-/	/kɾ-/	/kʋ-/
	mean	108.71		100.38		83.13	99.46	102.01
	st. dev.	24.03		26.64		23.30	27.99	30.28

Table 3.8 Mean stop closure duration in ms and standard deviations for simple and complex onsets

Closure duration is typically shorter in complex onsets than it is in simple onsets; the only exception is /p/, where the durations are mostly the same. It is also interesting to note that labials

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[50] Colantoni & Steele (2011) examine vowel epenthesis in Quebec French and Argentine Spanish, comparing stop-lateral and stop-rhotic clusters; their results are in many ways similar to what I find in Oslo Norwegian, with more epenthesis before rhotics. They interpret vowel epenthesis as a type of dissimilation, but that does not seem to be the case here.

are slightly longer than alveolars, which are in turn slightly longer than velars, and that LENIS stops tend to be slightly longer than FORTIS stops. A two-way ANOVA was calculated for the bare stops only, with the LENIS/FORTIS distinction and place of articulation as independent variables:

LENIS/FORTIS	F (1, 182) = 2.05	*p* = 0.1543
Place	F (2, 182) = 2.84	*p* = 0.0612
Both	F (2, 182) = 0.11	*p* = 0.8967

Table 3.9 Two-way ANOVA for closure duration

As the results show, there is no statistically significant difference in closure duration for either the LENIS/FORTIS distinction or place of articulation. Additionally, the results show that the difference in closure duration between LENIS and FORTIS stops, with LENIS stops being slightly longer, is not statistically significant. A one-way ANOVA was also calculated for stop closure duration in stop-sonorant clusters, with the LENIS/FORTIS distinction as the independent variable, but the results did not reach statistical significance (F (1, 533) = .045, *p* = 0.5035); we can therefore conclude that closure duration is essentially identical for LENIS and FORTIS stops in word-initial position in Oslo Norwegian.

3.5.1.2. VoffT (pulsing duration)

VoffT measures the duration of the voicing tail, or the continuance of glottal pulsing from the preceding vowel into the stop closure. Here are the results for bare stops, with pooled results below:

LENIS	mean VoffT in ms	s.d.	FORTIS	mean VoffT in ms	s.d.
/b-/	83.43	22.20	/p-/	30.78	11.49
/d-/	86.75	24.00	/t-/	29.92	11.85
/g-/	68.44	25.08	/k-/	27.14	12.71
pooled	79.54	23.76	pooled	29.28	12.01

Table 3.10 Mean VoffT in ms and standard deviations for bare stops

Some observable differences were noticed for both the LENIS/FORTIS distinction and place of articulation. A two-way ANOVA was calculated for VoffT, with the LENIS/FORTIS distinction and place of articulation as independent variables, with the following results:

LENIS/FORTIS	F (1, 179) = 325.50	$p < 0.0001$	omega^2 = 0.62
Place	F (2, 179) = 5.71	$p = 0.0040$	omega^2 = 0.02
Both	F (2, 179) = 3.41	$p = 0.0352$	omega^2 = 0.01

Table 3.11 Two-way ANOVA for VoffT

These results show a main effect for both LENIS/FORTIS and place of articulation and an interaction. Although the differences for place of articulation are highly statistically significant, the effect size is rather small. We can interpret these results to mean that the difference in VoffT is greatest between LENIS stops and FORTIS stops, which is not surprising. It is perhaps also not surprising that VoffT is shorter for velar stops than for alveolar or labial stops; this can be attributed to a smaller supraglottal volume behind a velar closure, which would cause the air pressure differential to be equalized sooner and inhibit transglottal airflow.

The pooled results for VoffT for stop-sonorant clusters were also calculated:

	mean VoffT in ms	s.d.
LENIS pooled:	77.47	24.18
FORTIS pooled:	24.24	12.26

Table 3.12 Mean VoffT for stops in clusters, pooled

A one-way ANOVA was also calculated, which shows the results to be highly significant (F (1, 465) = 851.69, $p < 0.0001$), with a large effect size (omega^2 = 0.65). The VoffT results for stop-sonorant clusters are quite similar to the results for bare stops.

3.5.1.3. % glottal pulsing

% glottal pulsing measures the ratio of VoffT to closure duration. The results for bare stops follow, with pooled results below:

LENIS	mean % pulsing	s.d.	FORTIS	mean % pulsing	s.d.
/b-/	67.85	19.78	/p-/	26.76	11.47
/d-/	76.55	22.49	/t-/	27.66	13.49
/g-/	61.68	23.27	/k-/	25.93	12.14
pooled	68.69	21.85	pooled	26.78	12.36

Table 3.13 Mean % pulsing and standard deviations for bare stops

Again, some differences are observable for both LENIS/FORTIS and place of articulation. A two-way ANOVA was calculated, with LENIS/FORTIS and place of articulation as independent variables:

LENIS/FORTIS	F (1, 179) = 253.90	$p < 0.0001$	omega^2 = 0.57
Place	F (2, 179) = 3.40	$p = 0.0357$	omega^2 = 0.01
Both	F (2, 179) = 2.58	$p = 0.0789$	omega^2 = 0.01

Table 3.14 Two-way ANOVA for % glottal pulsing

There is a main effect for both LENIS/FORTIS and place but no interaction, and the effect size for place is rather small. It is worth mentioning that even in a voiced environment (V#CV), only 5 /b-/ tokens, 11 /d-/ tokens, and 2 /g-/ tokens (or 18.95% of 95 LENIS tokens) are 100% voiced. This is an indication that there is no consistent active voicing gesture for LENIS stops in Oslo Norwegian; however, these results do not preclude the possibility that LENIS stops are sometimes – or perhaps even often – produced with an active voicing gesture.

The pooled results for % glottal pulsing for stop-sonorant clusters are provided below:

	mean % pulsing	s.d.
LENIS pooled:	77.15	21.78
FORTIS pooled:	22.14	12.02

Table 3.15 % Pulsing for stop-sonorant clusters, pooled

A one-way ANOVA was calculated for these results, which shows the difference to be highly significant (F (1, 465) = 1085.44, $p < 0.0001$), with a large effect size (omega^2 = 0.70). In this case, LENIS stops appear to be voiced approximately 10% longer in clusters than bare. This difference is likely due to the shortening that takes place in clusters; the stop itself has become slightly shorter, but VoffT duration has remained the same, thereby changing the ratio. Additionally, a much higher percentage of LENIS stops are fully voiced in clusters (35.18%, or

89 out of 253 LENIS tokens) than bare (18.95%); this is also perhaps due in part to the shorter closure duration in clusters.[51]

3.5.1.4. VOT

VOT for bare stops:

LENIS	mean VOT in ms	s.d.	FORTIS	mean VOT in ms	s.d.
/b-/	13.22	5.41	/p-/	56.11	16.78
/d-/	26.60	10.61	/t-/	62.28	15.11
/g-/	27.33	5.89	/k-/	70.45	11.92
pooled	22.38	7.30	pooled	62.95	14.60

Table 3.16 Mean VOT in ms and standard deviations for bare stops

When compared to the results reported by Halvorsen (pooled across three different dialects in her study: Bergen, Trondheim, and Eastern Norwegian), her results show generally shorter mean VOT for LENIS stops,[52] but her results for FORTIS are almost identical to mine, and the FORTIS results by place of articulation are also quite similar:

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[51] Cf. Dochtery (1992:119-120), who reports only 2.9% of LENIS stops as fully voiced in the same environment for British English.

[52] Halvorsen's results for word-initial LENIS stops show a bimodal distribution of VOT lead, or prevoicing, and VOT lag; here I show only her VOT lag results. She states that "[v]oicing lead was more frequent than voicing lag with a ratio 2:1" but the results varied considerably by speaker (1998:64-65).

LENIS	mean VOT in ms	s.d.	FORTIS	mean VOT in ms	s.d.
/b-/	9	7	/p-/	56	21
/d-/	12	6	/t-/	64	21
/g-/	24	11	/k-/	74	19
pooled	14	10	pooled	65	22

Table 3.17 Halvorsen's VOT results for LENIS (1998:63) and FORTIS (1998:80)

As mentioned, these results are pooled across three dialects. If we consider Halvorsen's results for Eastern Norwegian separately (which she only provides for FORTIS stops, not LENIS), the VOTs are longer: /p/ 68 ms, /t/ 76 ms, and /k/ 82 ms. However, she does not state precisely where her Eastern Norwegian speakers are from. It is also worth noting that my results for VOT after FORTIS stops in Oslo Norwegian are slightly lower than that reported for American English by Tsuchida et al., at 70 ms (2000:174).[53]

Similar to what has been reported for Norwegian (Halvorsen 1998:63-100) and other 'aspirating' languages (Lisker & Abramson 1964 for English, Hoole & Bombien 2014 for German, Hutters 1985 for Danish, and Helgason & Ringen 2008 for Swedish), there is a difference in VOT between LENIS and FORTIS stops as well as place of articulation, with labials having the lowest VOT and velars having the highest. A two-way ANOVA was calculated for this measure as well:

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[53] Docherty's results for VOT in British English are also similar to what I found for Oslo Norwegian (usually not more than 5 ms difference), though his results for /p/ are lower, at 41.54 ms mean VOT (1992:116).

LENIS/FORTIS	F (1, 183) = 569.74	$p < 0.0001$	omega^2 = 0.70
Place	F (2, 183) = 24.23	$p < 0.0001$	omega^2 = 0.06
Both	F (2, 183) = 3.08	$p = 0.0484$	omega^2 = 0.01

Table 3.18 Two-way ANOVA for VOT in bare stops

There is a main effect for both LENIS/FORTIS and place, and also an interaction, but place and especially the interaction have small effect sizes; 70% of the observed variation in VOT is due to the LENIS/FORTIS distinction, while only 6% is due to differences in place of articulation. These VOT results are not surprising for an ‘aspirating’ language.

VOT results for stop-sonorant clusters are also provided, pooled by place of articulation (this measure includes any devoicing of a following sonorant):

LENIS	mean VOT in ms	s.d.	FORTIS	mean VOT in ms	s.d.
/bj-/	14.20	13.50	/pj-/	72.31	16.89
/bl-/	14.55	8.07	/pl-/	59.12	18.97
/bɾ-/	13.15	6.25	/pɾ-/	55.65	23.99
pooled	13.97	9.68	pooled	62.36	21.22
/dɾ-/	24.09	9.83	/tɾ-/	72.12	21.39
/dʋ-/	20.75	8.42	/tʋ-/	93.56	22.41
pooled	22.42	9.23	pooled	82.84	24.27
/gl-/	23.65	10.65	/kl-/	80.14	23.01
/gn-/	19.32	8.52	/kn-/	83.24	12.04
/gɾ-/	24.34	12.62	/kɾ-/	72.88	21.84
			/kʋ-/	75.28	14.46
pooled	22.44	10.85	pooled	77.88	18.67

Table 3.19 Mean VOT in ms for stop-sonorant clusters

By way of comparison, Docherty (1992:118) provides VOT results for stop-sonorant clusters in British English, though VOT in his results are higher (in some cases, much higher) than the results for Oslo Norwegian here. Here are the overall pooled VOT results for stop-sonorant clusters:

	mean VOT in ms	s.d.
LENIS pooled:	19.26	10.80
FORTIS pooled:	73.81	22.41

Table 3.20 Mean VOT in ms for stop-sonorant clusters, pooled

A one-way ANOVA was also calculated for the stop-sonorant clusters pooled results, showing the observed differences in VOT to be highly significant (F (1, 542) = 1257.66, $p < 0.0001$) with a large effect size (omega^2 = 0.70). It is interesting to note the overall drop in VOT for LENIS stop-sonorant clusters compared to bare LENIS stops (22.38 ms), and also the overall increase in VOT for FORTIS stop-sonorant clusters compared to bare FORTIS stops (62.95 ms), though the standard deviations are also greater for both LENIS and FORTIS stops in clusters. However, the results for FORTIS stop-sonorant clusters here are also lower than that reported for English by Tsuchida et al., which is 89 ms (2000:174).

3.5.1.5. Sonorant duration

The following compares mean sonorant duration in simple and complex onsets, following stops; these results include any devoiced portion of the sonorant:

		bare	/b__/	/p__/	/d__/	/t__/	/g__/	/k__/
j		/j-/	/bj-/	/pj-/				
	mean	94.42	78.54	67.57				
	st. dev.	28.25	19.05	15.55				
l		/l-/	/bl-/	/pl-/			/gl-/	/kl-/
	mean	96.27	59.57	58.41			64.08	67.38
	st. dev.	27.74	10.83	12.87			18.66	12.50
m		/m-/						
	mean	113.50						
	st. dev.	27.44						
n		/n-/					/gn-/	/kn-/
	mean	103.64					69.27	64.86
	st. dev.	23.64					12.50	10.82
r		/ɾ-/	/bɾ-/	/pɾ-/	/dɾ-/	/tɾ-/	/gɾ-/	/kɾ-/
	mean	35.30	25.56	27.03	27.36	27.69	28.30	29.64
	st. dev.	10.10	7.62	9.02	11.83	10.34	9.87	9.99
v		/ʋ-/			/dʋ-/	/tʋ-/		/kʋ-/
	mean	83.69			69.11	76.93		62.03
	st. dev.	21.31			14.95	27.62		12.99

Table 3.21 Mean sonorant duration in ms and standard deviations following stops

While there are some noticeable differences in sonorant duration after various stops, it is clear that in each case, a bare sonorant is much longer than a sonorant in a cluster, and the difference in duration appears to be greater for bare sonorants vs. sonorants in clusters than it is for bare stops vs. stops in clusters. These comparisons are meaningful in that they illustrate that there is some shortening of segments in clusters.

3.5.1.6. Sonorant devoicing and % sonorant voicing

These measures overlap with VOT above, and are also affected by schwa epenthesis; as noted above, approximately two-thirds of all /pɾ-, tɾ-, kɾ-/ clusters showed schwa epenthesis. Therefore, no Cr- clusters are included due to the high rates of schwa epenthesis observed in these clusters even after FORTIS stops. However, pooled VOT for FORTIS stops in clusters is 73.81 ms; the duration of sonorant devoicing in the results below is typically half that. It is possible that schwa epenthesis is responsible for some of this difference; since there are for the most part only minor differences in sonorant duration after FORTIS vs. LENIS stops, the shorter duration of sonorant devoicing compared to VOT could be due to a delayed articulation of the sonorant. The following results show mean sonorant devoicing duration, mean % sonorant voicing, the number of fully devoiced sonorants (%0 voicing), and the number of fully voiced sonorants (100% voicing). The results are for FORTIS stops only. There were four /bj-/ tokens with some sonorant devoicing (two from F2 (ca. 20 ms devoiced) and two from F3 (ca. 45 ms devoiced)) and a single /gl-/ token showed some sonorant devoicing (14 ms, again from speaker F3).

Results for sonorant devoicing and % sonorant voicing, FORTIS stops (32 tokens in each category):

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/pj-/	47.72	19.13	29.77	22.14	6	0
/pl-/	33.16	18.29	43.67	28.34	3	4
/kl-/	37.92	15.33	44.03	20.00	2	0
/kn-/	32.40	10.42	48.39	20.07	2	0
/tʋ-/	31.60	27.41	61.68	31.77	2	10
/kʋ-/	25.92	22.25	58.61	36.15	5	10
pooled	34.79	20.44	47.69	28.77	20	24

Table 3.22 Mean sonorant devoicing in ms and % sonorant voicing for FORTIS stops

Additionally, even though Cr- clusters are not included here, it is worth noting that sonorant devoicing does take place in those clusters: /pɾ-/ had nine devoiced tokens, /tɾ-/ had eight, and /kɾ-/ had nine (mostly from speakers F2, F3, and F4, though speakers F1 and M1 each had a few). However, because the duration of /ɾ/ is so short, it is essentially all-or-nothing when it comes to sonorant devoicing of /ɾ/.

These results show that there is usually at least some remaining voiced portion of the sonorant after FORTIS stops, and occasionally all of the sonorant is voiced. As noted above, the fact that some sonorants are fully voiced after a FORTIS stop can partially be attributed to schwa epenthesis. Recall that for LENIS stop-sonorant clusters, /ɾ/ showed schwa epenthesis almost all of the time, /n/ and /ʋ/ each showed schwa epenthesis 71.88% of the time, and /l/ showed the least (but still some). In FORTIS stop-sonorant clusters, /ɾ/ showed schwa epenthesis approximately two-thirds of the time, there was no observable schwa epenthesis before /n/, some before /ʊ/, and one instance before /l/ (which turned out to be retroflex flap [ɽ]). This is reflected in the results above, with /tʊ-/ and /kʊ-/ each having 10 (out of 32) with a fully voiced sonorant. Figures 3.2 and 3.3 illustrate sonorant devoicing of /l/ in *plaske* 'to splash' and of /n/ in *knapper* 'buttons'. Notice that the devoiced portion of the /l/ might more accurately be described as a voiceless lateral fricative than a sonorant. The devoiced portion of the /n/, on the other hand, is marked by a sharp reduction in noise and intensity as the air flows through the nasal cavity. The visible preaspiration in these figures will be discussed below.

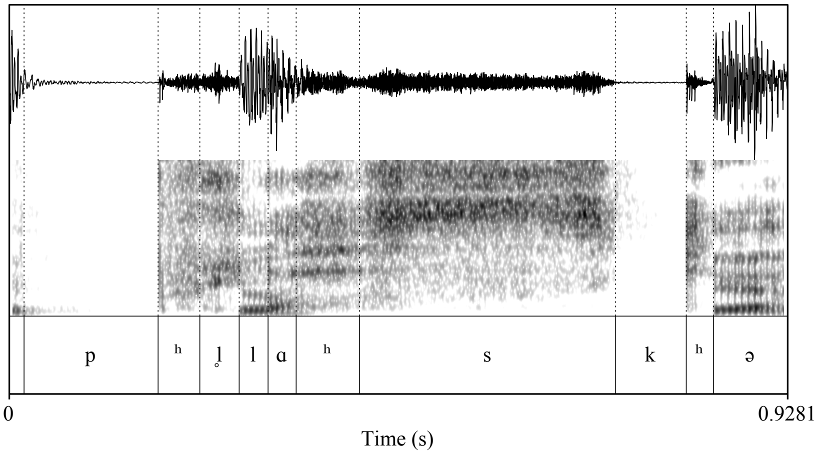


Figure 3.2 Speaker M1: ***plaske*** **'to splash' showing partial devoicing of /l/ (and preaspiration of /s/)**

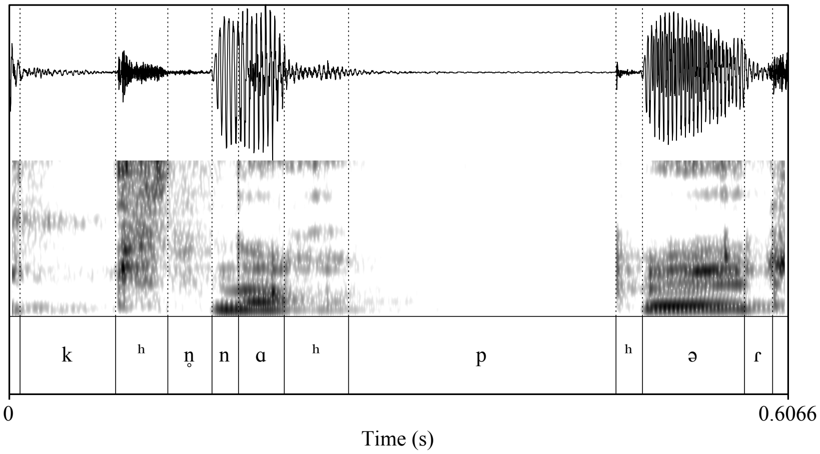


Figure 3.3 Speaker F2: ***knapper*** **'buttons' showing partial devoicing of /n/ (and preaspiration of /p/)**

3.5.1.7. Sonorant voicing duration

As a corollary to the previous section, I also include sonorant voicing duration for LENIS and FORTIS stop-sonorant clusters. In terms of acoustics, it is perhaps more straightforward to measure the voiced portion of a sonorant than the devoiced portion, especially if the devoiced portion is realized with frication that could get lost in the noise of aspiration. It also allows for a more meaningful side-by-side comparison of LENIS and FORTIS stop-sonorant clusters than sonorant devoicing alone:

LENIS	mean son. voi. in ms	s.d.	FORTIS	mean son. voi. in ms	s.d.
/bj-/	74.33	22.35	/pj-/	19.85	16.35
/bl-/	59.57	10.83	/pl-/	25.25	17.07
/gl-/	63.64	17.54	/kl-/	29.46	13.74
/gn-/	69.27	12.50	/kn-/	32.46	15.82
/dʋ-/	69.11	14.95	/tʋ-/	45.33	22.03
			/kʋ-/	36.11	22.60

Table 3.23 Mean sonorant voicing duration in ms and standard deviations

These results show that with the exception of /tʋ-/, the voiced portion of a sonorant is on average more than 30 ms shorter following a FORTIS stop than a LENIS stop. If we assume a sonorant is more or less the same duration whether it follows a LENIS or FORTIS stop, these results confirm the results above for sonorant devoicing and % sonorant voicing that show more than 50% of a sonorant is devoiced after a FORTIS stop.

3.5.2. Fricatives

3.5.2.1. Fricative duration

The following compares fricative duration, but in this case, there are only three fricatives (or, perhaps more accurately, two fricatives /s, f/ and an approximant /ʋ/), and a LENIS/FORTIS contrast between /ʋ/ and /f/ only:

		bare	/j/	/l/	/m/	/n/	/ɾ/	/ʋ/
v		/ʋ-/					/ʋɾ-/	
	mean	83.69					103.61	
	st. dev.	21.31					26.23	
f		/f-/	/fj-/	/fl-/		/fn-/	/fɾ-/	
	mean	136.95	132.66	127.98		153.49	146.31	
	st. dev.	24.38	28.24	32.38		29.70	33.75	
s		/s-/		[ʂɭ-]	/sm-/	/sn-/		/sʋ-/
	mean	160.60		143.71	151.42	143.08		159.38
	st. dev.	28.33		30.33	35.60	40.56		31.54

Table 3.24 Mean fricative duration in ms and standard deviations for simple and complex onsets

Here, the differences in duration between bare /ʋ/, /f/, and /s/ are far more obvious than the differences between stop durations above. However, fricative durations in fricative-sonorant clusters vary quite a bit; for example, duration is longer in bare /s-/ than in clusters (as might be expected), but shorter in /f-/ than in /fn-/ or /fɾ-/, and shorter in bare /ʋ-/ than in /ʋɾ-/.

3.5.2.2. VoffT (pulsing duration) for fricatives

	mean VoffT in ms	s.d.
/ʋ-/	71.96	19.87
/f-/	22.37	10.82
/s-/	12.05	8.14

Table 3.25 Mean VoffT in ms for bare fricatives

Compared to the results for VoffT in bare stops (29.28 ms), VoffT in bare fricatives is lower for /f/ and even lower for /s/.

Pooled VoffT for fricative-sonorant clusters:

	mean VoffT in ms	s.d.
/ʋɾ-/	95.13	29.50
/f/	19.93	11.66
/s/	11.74	5.13

Table 3.26 Mean VoffT in ms for fricatives in clusters

Again, VoffT is slightly lower for /f/ and much lower for /s/ than VoffT in stop-sonorant clusters (24.24 ms).

3.5.2.3. % Glottal pulsing for fricatives

	mean % pulsing	s.d.
/ʋ-/	87.25	17.96
/f-/	17.08	9.50
/s-/	7.56	4.97

Table 3.27 Mean % glottal pulsing for bare fricatives

The number of /ʋ-/ tokens with 100% glottal pulsing is 20 out of 32, or 62.5%, which is much higher than the 18.95% of bare LENIS stops.

% glottal pulsing for fricative-sonorant clusters:

	mean % pulsing	s.d.
/ʋɾ-/	92.55	18.44
/f/	15.18	9.87
/s/	8.34	4.11

Table 3.28 Mean % glottal pulsing for fricatives in clusters

The number of /ʋɾ-/ tokens with 100% glottal pulsing is 27 out of 32, or 84.38%; this is also much higher than the 35.18% reported above for LENIS stop-sonorant clusters.

3.5.2.4. Sonorant duration following fricatives

		bare	/ʋ__/	/f__/	/s__/
j		/j-/		/fj-/	
	mean	94.42		56.95	
	st. dev.	28.25		14.40	
l		/l-/		/fl-/	[ʂɭ-]
	mean	96.27		59.28	61.36
	st. dev.	27.74		14.40	17.32
m		/m-/			/sm/
	mean	113.50			80.56
	st. dev.	27.44			14.64
n		/n-/		/fn-/	/sn-/
	mean	103.64		86.05	72.76
	st. dev.	23.64		16.95	21.42
r		/ɾ-/	/ʋɾ-/	/fɾ-/	
	mean	35.30	26.77	28.03	
	st. dev.	10.10	8.53	10.72	
v		/ʋ-/			/sʋ-/
	mean	83.69			52.79
	st. dev.	21.31			10.79

Table 3.29 Sonorant duration bare and following a fricative

As with the results for sonorant duration in stop-sonorant clusters above, sonorants in clusters are much shorter than bare sonorants (with the exception of /ɾ/).

3.5.2.5. Fricative sonorant devoicing and % sonorant voicing

As with the stops, sonorant devoicing of /ɾ-/ will not be considered here due to near-universal schwa epenthesis. However, I will mention that 3 out of 32 /fɾ-/ tokens had a devoiced [ɾ̥], which is lower than the 8 or 9 each for /pɾ-/, /tɾ-/, and /kɾ-/.

Sonorant devoicing of /fj-/:

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/fj-/	30.04	13.97	46.76	22.80	0	3

Table 3.30 Mean sonorant devoicing in ms of /fj-/

Sonorant devoicing of Fl-:

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/fl-/	24.88	15.37	57.59	24.51	2	3
[ʂɭ-]	33.47	12.58	43.58	21.94	1	1

Table 3.31 Mean sonorant devoicing in ms for Fl- clusters

Here we see that roughly 50% of the sonorant is devoiced in /fj-/ and Fl- clusters. Figure 3.4 shows a mostly devoiced /l/ in *slappe* ‘to loosen’, but in contrast to *plaske* in Figure 3.2 above, there is a lowering of frication and intensity, at least relative to the preceding /s/.

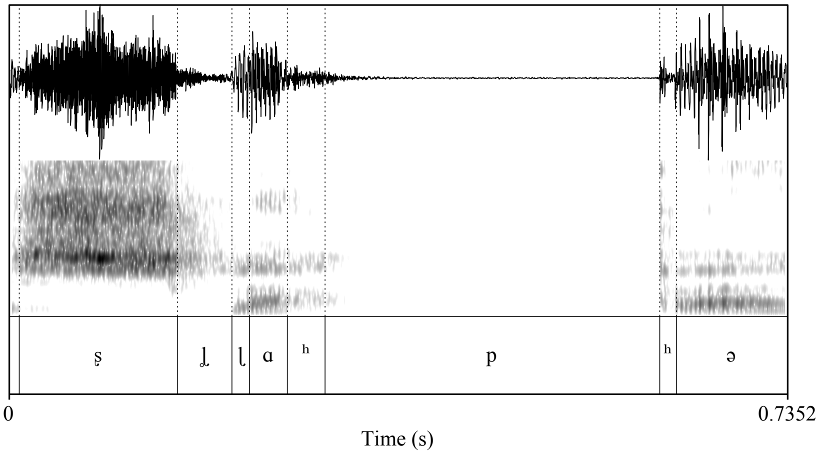


Figure 3.4 Speaker F4: *slappe* 'to loosen', showing a mostly devoiced /l/ (and preaspiration of /p/)

Sonorant devoicing of Fn-:

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/fn-/	18.35	12.12	78.12	15.21	0	5
/sn-/	24.02	8.70	65.56	12.68	0	0

Table 3.32 Mean sonorant devoicing in ms for Fn- clusters

Sonorant devoicing of /sm-/:

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/sm-/	23.88	9.26	69.70	12.35	0	2

Table 3.33 Mean sonorant devoicing in ms for /sm-/

We see from the results for /fn-/, /sn-/, and /sm-/ that the nasals seem to be more resistant to devoicing after fricatives than after /kn-/. However, the results show that there is still some devoicing of nasals after fricatives. Figures 3.5 and 3.6 show partial devoicing of /n/ in *fnyse* 'to snort' and of /m/ in *smitte* 'to infect'.

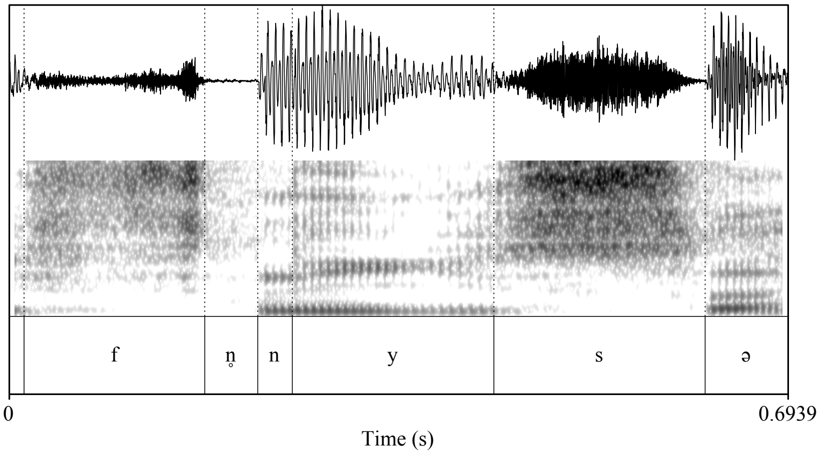


Figure 3.5 Speaker M1: *fnyse* 'to snort', showing partial devoicing of /n/

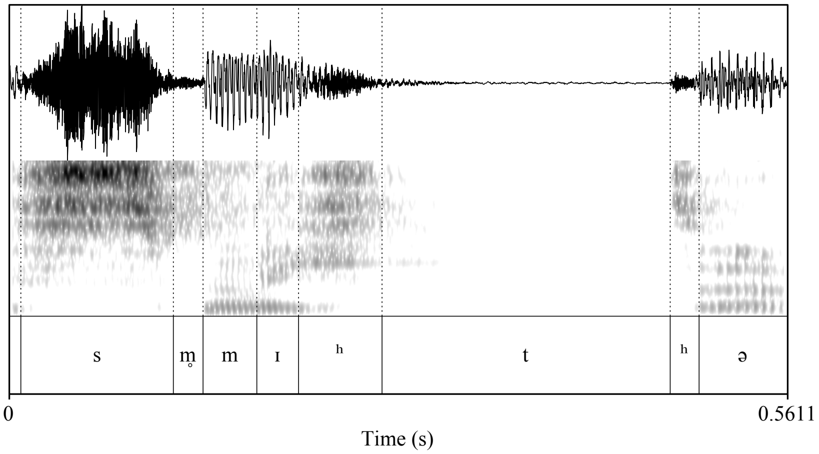


Figure 3.6 Speaker F5: *smitte* 'to infect', showing partial devoicing of /m/ (and preaspiration of /t/)

Sonorant devoicing of /sʊ-/:

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/sʊ-/	15.75	19.16	69.80	36.21	5	14

Table 3.34 Mean sonorant devoicing in ms for /sʊ-/

For /sʋ-/ there is much less sonorant devoicing; recall that 11 out of 32 (34.38%) /sʋ-/ tokens show schwa epenthesis; here, we see that 43.75% of all /sʋ-/ clusters have a fully voiced sonorant. However, there are also a few where the entire sonorant is devoiced. Figure 3.7 illustrates a fully devoiced /ʋ/, which I have transcribed here as a voiceless approximant [ʋ̥] because it lacks the noisy frication of /f/, but it is also often the case that a devoiced /ʋ/ has this frication.

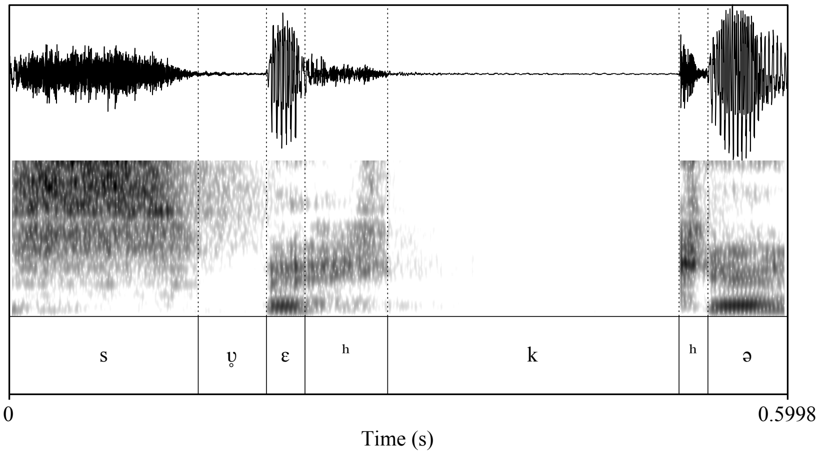


Figure 3.7 Speaker F2: ***svekke*** **'to impair', showing full devoicing of /ʋ/ (and preaspiration of /k/)**

3.5.3. Stop/fricative comparison

The results so far indicate that FORTIS fricatives generally show less sonorant devoicing than FORTIS stops, but it is also true that they do induce sonorant devoicing. As mentioned previously, one of the more salient realizations of a [spr gl] specification on a FORTIS stop is aspiration and sonorant devoicing. However, it is difficult to compare sonorant devoicing between fricatives due to the fact that the only LENIS/FORTIS comparison that could be made is between /ʋɾ-/ and /fɾ-/; however, due to the high frequency of schwa epenthesis before /ɾ/, this is not a meaningful comparison.

There is, however, the possibility of comparing FORTIS stops to FORTIS fricatives. The most likely candidate is clusters with /l/, because we have both /pl-/ and /kl-/ for stops and /fl-/ and /sl-/ for fricatives. Additionally, /l/ tends to show the least degree of schwa epenthesis. If the same degree of sonorant devoicing exists after /fl-/ and /sl-/ as it does after /pl-/ and /kl-/, then we have some evidence that would support a [spr gl] specification for FORTIS fricatives in Oslo Norwegian.

A series of ANOVAs were calculated for sonorant duration, sonorant devoicing, % sonorant voicing, and sonorant voicing duration, with manner of articulation (stop/fricative) as the independent variable, to determine whether any of the observed differences between stops and fricatives are statistically significant. The results follow:

	mean Cl-	mean Fl-	F (1, 126) =	*p* value	omega^2
son. duration	62.90	60.32	0.99	0.3224	n.s.
son. devoicing	35.54	29.17	5.20	0.0242	0.03
% son. voicing	43.85%	50.58%	2.47	0.1183	n.s.
son. voi. dur.	27.35	31.15	1.71	0.1930	n.s.

Table 3.35 ANOVA results for sonorant duration, sonorant devoicing, and % sonorant voicing for Cl-/Fl-

The results show that the only statistically significant difference is in sonorant devoicing, but the effect size is small. However, stops and fricatives show no statistically significant difference in overall % sonorant voicing or in the duration of the voiced portion of the sonorant; the combined results for all measures indicate similar behavior between FORTIS stops and fricatives.

3.5.4. Preaspiration

One unanticipated result from this experiment is the presence of widespread preaspiration. Preaspiration has been reported for other NGmc languages (Helgason 1999 for a dialect of Swedish, Ringen 1999 for Icelandic, van Dommelen & Ringen 2007 for Trøndelag Norwegian, and especially Helgason 2002 and references therein), but as far as I am aware, it has not been reported for Oslo Norwegian. I have already shown several examples of preaspiration above, for *plaske* (Fig. 3.2), *knapper* (Fig. 3.3), *slappe* (Fig. 3.4), *smitte* (Fig. 3.6), and *svekke* (Fig. 3.7). While it is likely less surprising to find preaspiration before FORTIS geminate stops in a NGmc language, finding it before FORTIS fricatives might be unexpected. However, the Oslo Norwegian speakers in this experiment consistently produced preaspiration before both stops and fricatives. Here are a few results for geminate stops:

token	mean dur. preasp. in ms	s.d.	n.
bakke ‘hill’	66.55	20.49	14
brekke ‘to break’	69.18	25.38	16
drikke ‘to drink’	61.73	21.34	16
glatte ‘to smooth’	67.91	15.36	16
godter ‘goodies’	57.92	16.65	16
gjette ‘to guess’	61.33	12.48	16
lette ‘to lighten’	65.19	15.68	16
nakke ‘neck’	68.52	24.48	16
nytte ‘to use’	68.15	19.31	16
vrikke ‘to twist’	73.56	23.00	16

Table 3.36 Preaspiration duration before geminate stops

Figure 3.8 is a token of *brekke* ‘to break’; the duration of preaspiration in this particular token is 103.24 ms.

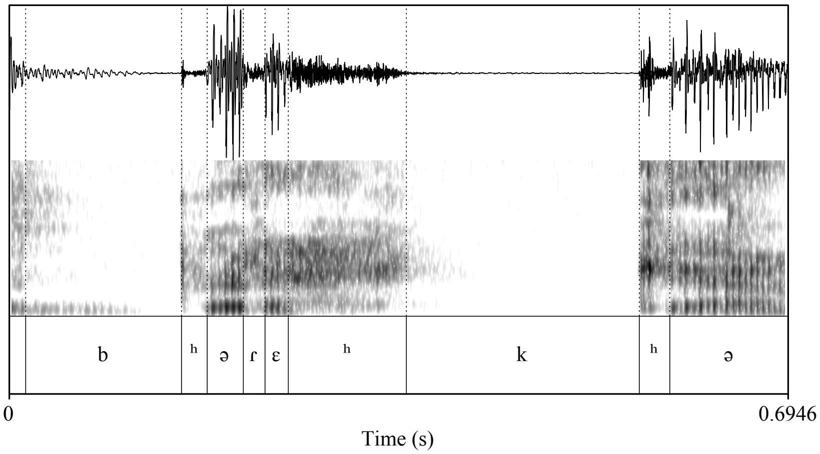


Figure 3.8 Speaker F3: *brekke* ‘to break’, showing 103.24 ms of preaspiration before /k/

The results before stop clusters are generally somewhat shorter:

token	mean dur. preasp. in ms	s.d.	n.
dyktig ‘capable’	43.99	14.86	12
frykte ‘to fear’	54.07	15.61	10
jakte ‘to hunt’	54.81	16.41	16
riktig ‘correct’	42.11	11.66	15
trakte ‘to aspire’	56.06	20.85	11

Table 3.37 Preaspiration duration before stop clusters

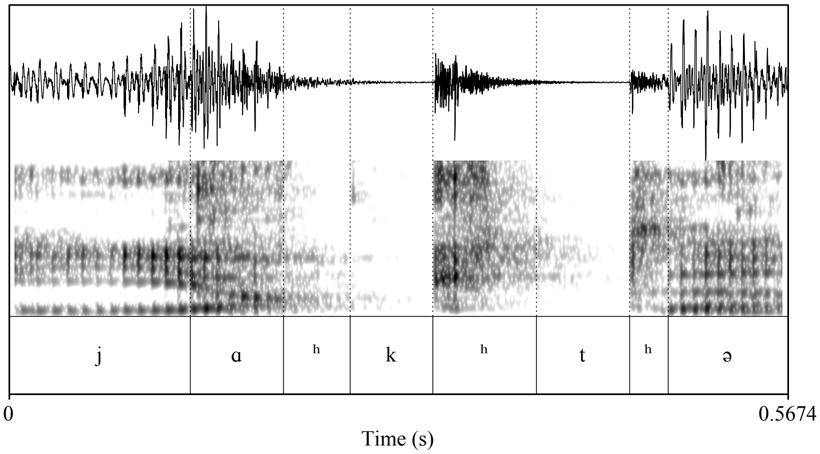


Figure 3.9 Speaker M3: ***jakte*** **'to hunt', showing preaspiration of /k/**

Geminate fricatives also show preaspiration:

token	mean dur. preasp. in ms	s.d.	n.
gasse 'to gas'	49.82	18.60	14
masse 'mass'	55.45	23.42	14
bløffe 'to bluff'	37.78	11.54	9
presse 'press'	40.58	16.12	13
klasse 'class'	53.99	16.19	13
kvasse 'keen'	56.82	19.51	14

Table 3.38 Preaspiration duration before geminate fricatives

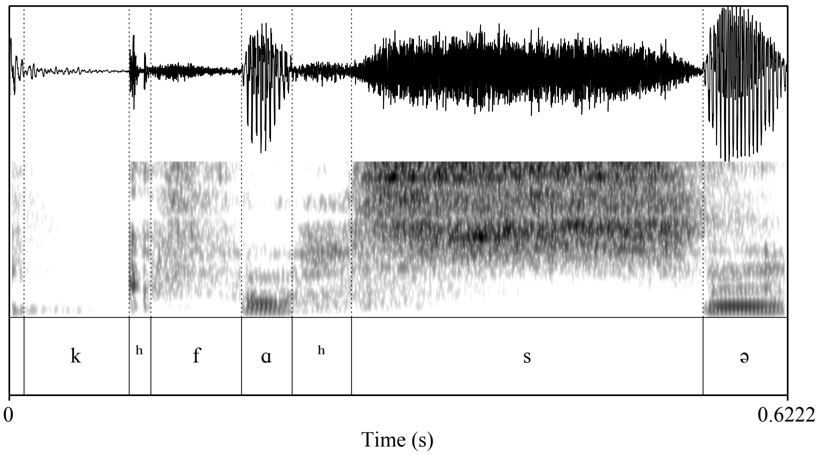


Figure 3.10 Speaker F2: *kvasse* 'keen', showing 43 ms of preaspiration before /s/

Preaspiration is also seen in fricative clusters (see also *plaske* in Fig. 2 above):

token	mean dur. preasp. in ms	s.d.	n.
raste 'to rest'	56.36	18.30	13
kaste 'to throw'	31.51	6.42	5
vaske 'to wash'	49.53	19.02	14
saftig 'juicy'	33.20	10.22	10
gnafse 'to munch'	46.02	16.07	14
grøfter 'ditch' pl.	35.90	12.97	8
plaske 'to splash'	45.72	18.17	14
kraftig 'powerful'	43.70	14.18	10
flaske 'bottle'	41.97	15.99	14

Table 3.39 Preaspiration duration before fricative clusters

Finally, singleton stops in *vrake* and *fjetre* (followed by a sonorant) also show preaspiration:

token	mean dur. preasp. in ms	s.d.	n.
vrake ‘to refuse’	57.72	14.08	15
fjetre ‘to bewitch’	63.28	18.28	15

Table 3.40 Preaspiration duration in *vrake* and *fjetre*

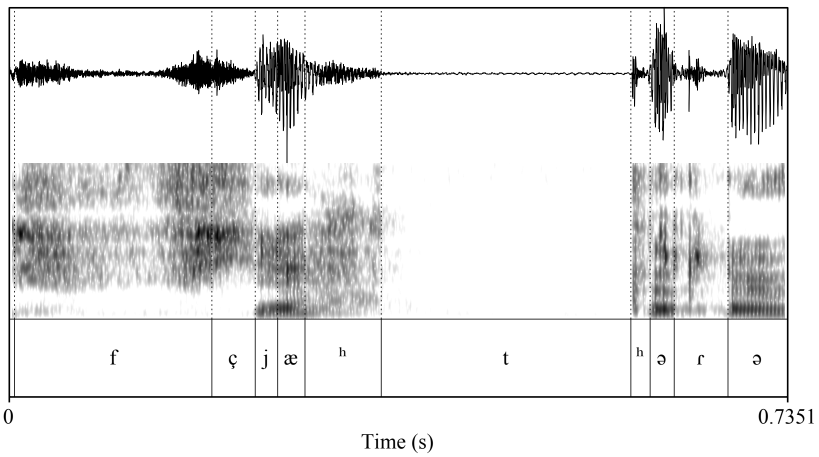


Figure 3.11 Speaker F1: *fjetre* ‘to bewitch’, showing 73.20 ms of preaspiration before /t/

Although there are some speaker differences with regard to preaspiration, there do not seem to be any gender differences; speaker M1 has some of the most consistent preaspiration (and among the longest in duration) while M3 has some of the shortest preaspiration and tends to lack preaspiration before fricatives. Since this experiment was not designed around preaspiration, there are some gaps in the data, mainly the lack of singleton FORTIS stops and LENIS stops in general for comparison. Given these results, this is a promising area for future research.

3.5.5. Regressive devoicing

For regressive devoicing, each word was uttered twice per speaker for a total of sixteen tokens, and the results are pooled below. Two conditions were found for regressive devoicing: preaspiration and voicing tail; preaspiration will be discussed when it is present.

Regressive devoicing of geminate /dː/ before /-s/:

token	mean V dur.	mean C dur.	mean VoffT	mean % puls.
forlodds ‘in advance’	97.04	119.07	107.51	90.43
tilladds	103.74	127.79	89.14	74.19

Table 3.41 Regressive devoicing of /dː/ before /-s/

Here we see that there is very little devoicing of geminate /dː/ before /s/. No preaspiration was found in this set.

Regressive devoicing of singleton /d/ before /-s/:

token	mean V. dur.	mean C dur.	mean VoffT	mean % puls.
fredsdagen	138.50	68.86	57.68	86.26
tilfreds	64.02	111.14	39.24	37.64

Table 3.42 Regressive devoicing of /d/ before /-s/; *fredsdagen* ‘liberation day’, *tilfreds* ‘satisfied’

There is regressive devoicing of word-final /ds/ in *tilfreds* (where /-s/ is the old genitive case marker; see Kristoffersen 2000:77), and compared to the results for bare /t/ above with 43.35 ms mean VoffT and 38.70% glottal pulsing, it seems that the contrast is neutralized here. A preaspiration condition was found for three tokens of *tilfreds* (speakers F3 and F4) with a mean duration of 60 ms. Additionally, *fredsdagen* and *tilfreds* both contain the same word *fred* ‘peace’, which has a long vowel followed by a singleton stop. This long vowel is retained in *fredsdagen*, but /d/ is considerably shorter than word-initial /d/ (or /t/) as reported above (100-120 ms). On the other hand, the vowel is much shorter in *tilfreds* while stop duration is closer to word-initial /d/.

Regressive devoicing of geminate /gː/ before /-s/:

token	mean V dur.	mean C dur.	mean VoffT	mean % puls.
avleggs	80.36	93.92	76.20	82.47
anleggsplan	69.32	61.16	59.06	97.09
tilleggsbevis	75.65	65.78	55.20	86.99

Table 3.43 Regressive devoicing of /gː/ before /-s/; *avleggs* ‘antiquated’, *anleggsplan* ‘construction plan’, *tilleggsbevis* ‘additional proof’

Regressive devoicing of singleton /g/ before /-s/:

token	mean V dur.	mean C dur.	mean VoffT	mean % puls.
allslags	54.63	97.94	38.93	46.38
gammeldags	70.26	91.19	38.18	42.62

Table 3.44 Regressive devoicing of /g/ before /-s/; *allslags* ‘of all kinds’, *gammeldags* ‘old fashioned’

Similar to /ds/ and /dːs/ above, there is little devoicing of geminate /gː/ and closure duration is shortened in compound words, but closure duration is almost identical for singleton /g/ and geminate /gː/ before /-s/ word-finally (ca. 91-98 ms). Once again, the difference is in the regressive devoicing of a singleton stop before /-s/; here, both singleton /gs/ tokens are word-final and more than halfway devoiced, and the contrast is likely neutralized (VoffT is the same as *tilfreds* above); cf. the results for bare /k/ above (mean VoffT: 36.12; mean % glottal pulsing: 36.00). For the preaspiration condition, there was one token of *allslags* (speaker F4, 53 ms) and three tokens of *gammeldags* (speakers F4 and F5, ca. 60 ms).

Although I did not include a compound word with /gs/ in the wordlist, we would expect it to behave similar to *fredsdagen* above. In fact, Kristoffersen cites an example of this type, indicating that it will retain the long vowel and not exhibit regressive devoicing; however, an almost identical example shows regressive devoicing (2000:78; Kristoffersen's transcription):

11) *lag* [lɑːg] 'team' *arbeid* [ɑɾbæj] 'work' *lagsarbeid* [lɑːg.sɑɾbæj] 'team work'
skog [skuːg] 'wood, forest' *skogsarbeid* [skuk.sɑɾbæj] 'lumbering'

We are left without an explanation as to what the difference could be, and this is a gap in my data.

Regressive devoicing of /ʋ/ before /-s/:

token	mean V dur.	mean C dur.	mean VoffT	mean % puls.
livserfaring	47.30	115.68	28.84	27.28
livsfarlig	42.59	131.48	28.04	23.74

Table 3.45 Regressive devoicing of /ʋ/ before /-s/; *livserfaring* 'life experience', *livsfarlig* 'perilous'

In contrast to *fredsdagen* above, both /ʋs/ tokens are mostly devoiced and the contrast is likely neutralized; the results for bare /f/ above show a mean VoffT of 23.22 ms and a mean % glottal pulsing of 17.95%, which is slightly lower than the results here. However, with approximately 75% of the fricative voiceless, it would likely be perceived as voiceless. Furthermore, these results match Kristoffersen’s prediction, with a short vowel and regressive devoicing (2000:77; Kristoffersen’s transcription):

12) *liv* [liːʋ] ‘life’ *livserfaring* [lif.sæfɑːɾiŋ] ‘experience in life’

Regressive devoicing before the nominalizing suffix -*sel*:

token	mean V dur.	mean C/F dur.	mean VoffT	mean % puls.
fødsel ‘birth’	40.90	89.27	29.61	39.24
redsel ‘fear’	51.58	91.65	16.55	21.49
trivsel ‘well-being’	40.85	135.17	30.45	30.16

Table 3.46 Regressive devoicing of an obstruent before -*sel*

All three are mostly devoiced. With similar results to *tilfreds* above, the contrast is likely neutralized for *fødsel* and *redsel*. There is also a preaspiration condition, with 8 tokens for *fødsel* (speakers F3, F4, F5, and M1; 56.85 ms) and 11 tokens for *redsel* (all speakers except M2 and M3; 59.64 ms).

The results for *trivsel* are slighltly higher than the results for *livserfaring* and *livsfarlig* above; however, since VoffT and & pulsing are similar for all three tokens before -*sel*, it is likely that the contrast is neutralized for all three. In the case of -*sel*, vowel length in the stem is irrelevant, and even geminate /dː/ is devoiced; according to Kristoffersen, devoicing before -*sel* is exceptionless (2000:78; Kristoffersen’s transcription, corresponding to the forms above):

13) *føde* [fəː.də] ‘to give birth’ *fødsel* [fœt.sl̩] ‘birth’

redd [ɾɛd] ‘afraid’ *redsel* [ɾɛt.sl̩] ‘fear’

trives [tɾiːʋəs] ‘to thrive’ *trivsel* [tɾif.sl̩] ‘well-being’

Regressive devoicing of /g/ and /gː/ before /-t/:

token	mean V dur.	mean C dur.	mean VoffT	mean % puls.
tregt ‘slow’ neut.	166.21	106.31	57.56	55.10
gløgt ‘smart’ neut.	56.18	105.33	25.40	24.78
trygt ‘safe’ neut.	48.64	106.86	38.43	37.78

Table 3.47 Regressive devoicing of /g/ or /gg/ before /-t/

In this case, *tregt* shows less devoicing than both *gløgt* and *trygt*, but the uninflected forms are *treg*, *gløgg*, and *trygg*, respectively; the difference being that *treg* has a long stem vowel (which it has obviously retained) while the latter two have a short one. However, unlike *avleggs* and *forlodds* above, both of which have a geminate stop in the stem but neither of which show much devoicing before /-s/, *gløgt* and *trygt* show significant regressive devoicing, a much shorter vowel length before the stop, and the geminate stop no longer appears in the orthography – an indication that there may be some lexical difference between the two suffixes. Since the results for bare /k/ above show a mean VoffT of 36.12 and a mean % glottal pulsing of 36.00, it is safe to say that the contrast is neutralized for *gløgt* and *trygt*, but only partially neutralized for *tregt*. There is also a preaspiration condition, with 8 tokens of *gløgt* showing preaspiration (speakers F3, F4, F5, and M1; 70 ms) and only 2 tokens of *trygt* (speaker F3, 65 ms).

Regressive devoicing of /ʋ/ before /-t/:

token	mean V dur.	mean C dur.	mean VoffT	mean % puls.
grovt ‘rough’ neut.	170.59	144.17	31.39	23.46
sløvt ‘blunt’ neut.	163.91	152.23	36.58	26.57
stivt ‘stiff’ neut.	151.84	136.89	36.81	28.15

Table 3.48 Regressive devoicing of /ʋ/ before /-t/

Similar to *treg*/*tregt* above, the long stem vowel has been retained (the stems are *grov* [gɾɔːʋ], *sløv* [ʂɭøːʋ], and *stiv* [stiːʋ], respectively); however, unlike *tregt*, there is much more regressive devoicing. The results for mean VoffT and mean % glottal pulsing are similar to *livserfaring*, *livsfarlig*, and *trivsel* above, so the contrast is likely neutralized.

Related to the discussion of preaspiration in the previous section, one of the items in the wordlist that targeted word-initial /bj-/ was *bjørker* ‘birches’. For this word, each of the eight speakers consistently produced a devoiced [ɾ̥k] sequence, with a mean duration of voicelessness of 121.97 ms (s.d. 46.66 ms) across all speakers, which is much longer than the normal duration of /ɾ/ alone at around 20-30 ms. Figure 3.12 shows a waveform and spectrogram of *bjørker* by speaker M1. This was by far the longest duration of devoiced /ɾ/ at approximately 234 ms (the shortest was 46 ms by speaker M3). The articulation of the /ɾ/ is visible (and audible in the recording), as it was for most other speakers, and is followed by a long period of voiceless frication (which I have transcribed as a voiceless alveolo-palatal fricative [ɕ]).

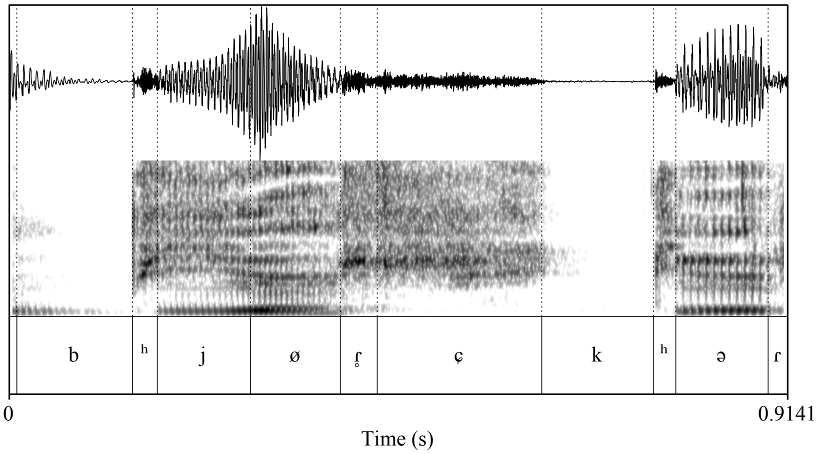


Figure 3.12 Speaker M1: ***bjørker*** **'birches'**

As noted in Section 3.3.2.2 above, Kristoffersen (2000:79) mentions that /ɾ/ devoices before a non-coronal FORTIS obstruent; this type of regressive sonorant devoicing was regularly produced by all speakers.

3.6. Analysis and conclusion

3.6.1. VoffT, VOT, and Sonorant Devoicing

Given previous work by Halvorsen (1998) and Ringen & van Dommelen (2013), as well as Kristoffersen's description of the LENIS/FORTIS distinction in UEN, the VOT results for Oslo Norwegian stops should come as no surprise; LENIS stops are almost always short-lag VOT while FORTIS stops are robustly long-lag VOT. Although a number of LENIS stops are 100% voiced, this is in a fully voiced environment (preceded and followed by phonetically voiced segments); we might expect to see a much higher number of 100% voiced LENIS stops in this environment if the LENIS stops were consistently articulated with an active voicing gesture. Instead, the majority of them show a voicing tail that tapers down to zero during the closure period, which indicates a general lack of an active voicing gesture, allowing the air pressure to build up behind the oral closure and cause spontaneous voicing to cease. However, it is possible that an examination of utterance-initial LENIS stops would reveal a bimodal distribution such as that found for Swedish (e.g. Helgason & Ringen 2008) or other varieties of Norwegian (Halvorsen 1998), or that an electromyographic study would show an active voicing gesture is present for some LENIS stops (e.g. Hirose 1977).

On the other hand, the VoffT results for the FORTIS stops show a much shorter voicing tail; it is possible that the earlier VoffT for FORTIS stops is the result of a glottal spreading gesture, forcing the vocal folds apart where they can no longer vibrate. This is in line with the transillumination results from Tsuchida et al. (2000), which show that the glottal opening gesture for American English FORTIS stops coincides with the onset of stop closure. The results presented in this chapter support an analysis where LENIS stops are laryngeally unspecified and FORTIS stops are specified for [spr gl]; in other words, laryngeal realism is supported.

Furthermore, *pace* Kristoffersen, the results of sonorant devoicing after FORTIS stops and FORTIS fricatives show that /s/, along with the other FORTIS obstruents, devoices a following sonorant. Additionally, the comparison of sonorant devoicing after FORTIS stops and FORTIS fricatives in Section 3.5.3 shows little or no significant difference between stops and fricatives, supporting a [spr gl] analysis for all FORTIS obstruents. This differs somewhat from the analysis put forth by Tsuchida et al. (2000) for English, whose results show that while FORTIS stops and FORTIS fricatives both have a glottal opening gesture in American English, a sonorant following a FORTIS stop is nearly completely devoiced (more than my results for Oslo Norwegian), but only a small portion of a sonorant is devoiced after FORTIS fricatives (less than my results for

Oslo Norwegian). Their results lead them to conclude that in American English, FORTIS stops are specified for [spr gl], FORTIS fricatives are laryngeally unspecified, and LENIS fricatives are specified for [voice]. The presence of a glottal spreading gesture in a laryngeally unspecified voiceless fricative is predicted by Vaux (1998), who argues that all voiceless fricatives are at least phonetically [spr gl] by default. In Oslo Norwegian, however, the evidence suggests that both FORTIS stops and FORTIS fricatives are phonologically [spr gl].

3.6.1.1. Is sonorant devoicing (progressive or regressive) phonetic or phonological?

If sonorant devoicing were simply a function of the glottal spreading gesture extending over the following segment, then we would also expect to see partially or fully devoiced vowels after FORTIS stops. This is not the case. Each of the bare stops (and most of the stops in clusters) in this experiment was followed by a short vowel and a FORTIS geminate obstruent or obstruent cluster of the shape CVCCV(C). If we compare vowel duration for LENIS and FORTIS stops, we see that vowel duration is essentially identical:

LENIS	mean V dur. in ms	s.d.	FORTIS	mean V dur. in ms	s.d.
/b/	37.35	12.36	/p/	35.65	14.65
/d/	40.21	9.79	/t/	38.16	12.27
/g/	38.29	11.26	/k/	38.37	12.51

Table 3.49 Mean vowel duration in ms with standard deviations for bare LENIS and FORTIS stops

Recall that this is after VOT, which is approximately 15-30 ms for LENIS stops and 60-70 ms for FORTIS stops. This means that speakers postpone the vowel segment until after the glottal spreading gesture, but sonorants aren't afforded the same courtesy; vowel devoicing does not take place after FORTIS stops (typically, though there was a small number of tokens where it did), but sonorant devoicing does. This becomes more apparent when we consider the results of the sonorant voicing duration measure above, where the voiced portion of the sonorant was consistently shorter after FORTIS stops than after LENIS stops. Clearly, the glottal spreading gesture is allowed to overlap the articulation of a sonorant, but not the articulation of a vowel.

It may also be important that VOT is slightly longer in obstruent-sonorant clusters; Tsuchida et al. (2000) show that the glottal gesture itself isn't longer, but rather VOT is longer because closure duration is shorter in clusters than in simple onsets before vowels. Thus there is clearly some difference between vowels and sonorants. It is difficult to think of any phonetic, articulatory reason why vowels are not devoiced while sonorants are, but one possible phonological explanation is that while vowels and sonorants are both [+sonorant], vowels are [–consonantal] and sonorants are [+consonantal]. It is possible, therefore, that the sharing (or spreading) of laryngeal specifications is limited to [+consonantal] segments; however, it seems to be optional for sonorants but obligatory for obstruents (see Kristoffersen 2000:56-57, 74-75 for voicing in obstruent clusters). Note that this would also extend to (most cases of) regressive devoicing, but in this case it usually does not extend to sonorants (unless /ʋ/ is analyzed as a sonorant; [grɔːʋ] + /-t/ = [grɔft]); as noted above, regressive devoicing of sonorants in coda position is typically limited to /ɾ/ in Norwegian, e.g. *skarp* [skɑɾ̥p] 'sharp' and *skjerf* [ṣæɾ̥f] 'scarf' (Kristoffersen 2000:79).

That sonorants are subject to devoicing while vowels are not suggests that sonorant devoicing is phonological rather than phonetic in that the glottal spreading gesture can only spread to other [+consonantal] segments. If we consider again the model of speech production proposed by

Keyser & Stevens (2006) (Section 2.5), then access to this phonological information must have occurred at the planning stage, i.e. in the phonology, because gestural overlap occurs at the phonetic level. In other words, if a [+consonant] cluster (both obstruents and sonorants are [+consonantal]) is planned in the phonology, and that cluster includes a phonologically specified [spr gl] segment, then the [spr gl] gesture spreads to the consonant cluster at that stage. This supports the view of Iverson & Salmons (1995) who argue that consonant clusters, including sonorant consonants, share a single laryngeal gesture.

At the phonetic level, a portion of the sonorant can become voiced after the glottal spreading gesture has ended because the conditions for spontaneous voicing have returned (the vocal folds are appropriately adducted and there is sufficient transglottal airflow). According to Tsuchida et al. (2000), the glottal gesture is aligned with the onset of stop closure and peak glottal opening often coincides with stop release, which results in either aspiration or sonorant devoicing; in many cases, even apparently in their results, the duration of the sonorant exceeds the duration of the glottal spreading gesture. Their results also include discussion of complex consonant clusters such as *skl-* where the transillumination data show a single glottal spreading gesture; here, the sonorant is completely voiced because the glottal spreading gesture only extends through the fricative and stop closures.

As I argued in Chapter 2, sonorants (or [+sonorant] segments, including vowels) are redundantly (or phonetically) voiced, so the feature [voice] is not contrastive, and therefore sonorants and vowels are both unspecified for laryngeal features. The only difference, then, is their phonological specification for the feature [consonantal]. If sonorant devoicing were the result of gestural overlap at the phonetic level, then we should also expect vowels to devoice; this evidence supports the claim that sonorant devoicing is phonological, due to a single [spr gl] specification that attaches to adjacent [+consonantal] segments in the phonology.

3.6.2. Regressive devoicing and preaspiration

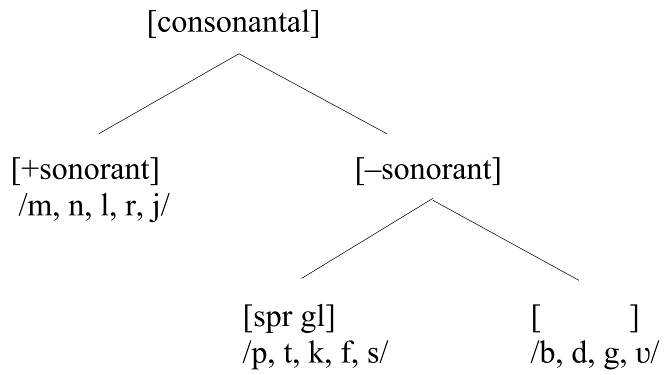
For the most part, the results match up with Kristoffersen's analysis of regressive devoicing. Clearly, /t/ induces regressive devoicing more regularly than /s/ does, and /s/ seems to be more sensitive to the shape of the stem (long vowel or short vowel with geminate stop) and varies in compound words (*fredsdagen* never exhibited regressive devoicing for any speakers, but it is always present in *livserfaring*). However, it is also clear that both /t/ and /s/ are capable of triggering regressive devoicing, even though /s/ sometimes does not. Moreover, we are discussing the absence of regressive devoicing before certain affixes, not the presence of regressive voicing. Thus the combined evidence of sonorant devoicing and regressive devoicing points to a [spr gl] specification for /s/ along with all other FORTIS obstruents in Oslo Norwegian. The preaspiration data also support this analysis, where all FORTIS obstruents, including fricatives, exhibit significant amounts of preaspiration. Regressive devoicing and preaspiration can be seen as part of the same process, which the tokens of e.g. *fødsel* and *gløgt* that exhibit preaspiration seem to suggest.

3.6.3. Contrastive hierarchy

In terms of a contrastive hierarchy, the data presented for UEN by Kristoffersen (2000) seem to require an ordering of features that would account for the special behavior of /s/. Ranking [continuant] and [place] features above [spr gl] would allow us to separate /s/ from the other obstruents before assigning [spr gl]. Alternatively, we could target /s/ directly by adding a feature [sibilant] to separate /s/ from all other FORTIS obstruents and rank [sibilant] somewhere above [spr gl]. If /s/ were truly unspecified laryngeally, then it would not appear to fit into any natural class; it would clearly not be a stop, but neither would it seem to pattern with the other continuants, because it is not voiced like /ʋ/ and, according to Kristoffersen, does not induce sonorant devoicing like /f/. It also does not undergo passive voicing like /b, d, g/, which are also laryngeally unspecified in this analysis, and even though /s/ is capable of inducing assimilation to voicelessness in clusters, it again apparently does not cause sonorant devoicing as do /p, t, k, f/.

The results presented above indicate the contrary, however, namely that /s/ behaves the same laryngeally as /p, t, k, f/ in Oslo Norwegian, exhibiting the same degree of sonorant devoicing, inducing regressive devoicing (with a few exceptions), and also showing preaspiration. This means that a straightforward [spr gl] analysis is supported, and that the contrastive hierarchy can account for the phonological behavior of /s/ despite its lack of a LENIS counterpart because a ranking of [sonorant] > [spr gl] would group all of the FORTIS obstruents /p, t, k, f, s/ into a natural class:[54]

14)



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[54] I assume this would also include Norwegian /ç/ and /s̪/, but it is difficult to find an environment to test these acoustically.

3.6.4. Implications

With respect to laryngeal features in NGmc more generally, Icelandic is well known for having a voicing contrast for sonorants as well as obstruents (e.g. Árnason 2011, Bombien 2006). According to Bombien (2006), the laryngeal distinction in sonorants may not be voiced vs. voiceless at the phonetic level; ‘voiceless’ sonorants can have continuous glottal pulsing, but are longer and show some frication, so there are phonetic differences other than voicing. Nevertheless, his results also show that voiceless sonorants are accompanied by a glottal spreading gesture in Icelandic, so we can argue that the voiceless sonorants are specified for [spr gl]. This can easily be accounted for in a contrastive hierarchy by ordering [spr gl] above [sonorant], which is the reverse of the ordering I have posited for Oslo Norwegian.

As noted previously, Ringen & Helgason (2004) (as well as Beckman & Ringen 2004, Beckman et al. 2011, and Helgason & Ringen 2008) argue on the basis of phonetic evidence that both [spr gl] and [voice] are active in Swedish, with both substantial voicing and prevoicing in the LENIS stops /b, d, g/, but also with progressive and regressive assimilation to voicelessness in clusters containing FORTIS stops /p, t, k/. From a theoretical standpoint, it seems problematic to have both features active in Swedish, especially since stops in clusters always assimilate to voicelessness, which would imply that only [spr gl] is active. At the very least, it seems that they provide ample evidence that /p, t, k/ are specified for [spr gl], while claiming [voice] for /b, d, g/ requires more maneuvering.

One explanation for the substantial voicing in Swedish /b, d, g/, based on the framework adopted here, is that phonetic enhancement serves to emphasize the difference between the two obstruent series by increasing the amount of glottal pulsing in /b, d, g/. In other words, [spr gl] is phonologically contrastive in Swedish obstruents and [voice] is acting as a phonetic enhancement in the LENIS series to boost the contrast between LENIS and FORTIS; this is predicted by Henton et al. (1992), who note that laryngeal distinctions are prone to enhancement. Having the FORTIS obstruents specified for [spr gl] and the LENIS stops specified for [voice] is not disallowed by the contrastive hierarchy *per se*, but some evidence of phonological activity – not just phonetic activity – is required by MCS and the SDA for the ordering of phonologically contrastive features. In the model proposed by Hall (2011) in Section 2.11, it is precisely this kind of phonetic activity that is seen as a phonetic enhancement rather than a contrastive phonological feature. The evidence presented in this chapter shows phonetic voicing of LENIS stops (though apparently not as substantial as in Central Standard Swedish), but the phonological evidence indicates that only [spr gl] is phonologically active.

Chapter 4: Dutch

4.1. Overview

Dutch is widely described as a ‘voicing’ language, where the feature [voice] (either binary or privative, depending on the analysis) is primarily responsible for distinguishing between /b/ and /p/, for example (Iverson & Salmons 1995, Lombardi 1999). As stated previously, I argue for laryngeal realism in this dissertation, namely that there is an underlying, phonological difference between ‘voicing’ and ‘aspirating’ languages. In the former, /b, d, g/ are specified for [voice] while /p, t, k/ are unspecified, and in the latter, /p, t, k/ are specified for [spr gl] while /b, d, g/ are unspecified. In terms of phonetic implementation of phonological [voice], in Section 2.2 I described how an (active or passive) expansion of the supraglottal cavity is required to maintain a pressure drop across the glottis to allow vocal fold vibration during stop closure. However, there is no one-to-one mapping between phonological specification and phonetic implementation; several studies (discussed below) reveal not only that there are multiple acoustic cues present in the production of Dutch LENIS obstruents, but also that there are active glottal spreading and devoicing gestures present in Dutch FORTIS (unspecified) obstruents. Thus [voice] does not necessarily refer only to vocal fold vibration, nor does a lack of phonological specification imply a lack of phonetic activity; this apparent discrepancy between phonology and phonetics is accounted for in Hall’s (2011) model of contrast and enhancement (Section 2.11).

Furthermore, as mentioned in Section 1.3.6, Dutch fricatives appear to be losing a voicing distinction altogether, with ‘voiced’ fricatives usually being realized as phonetically voiceless (more on this below). In addition to the phonetic differences between ‘voiced’ stops and fricatives, there are also phonological differences. One of the classic problems of Dutch phonology is the assimilation process (regressive voice assimilation, or RVA) whereby voiceless obstruents become voiced before voiced stops /b, d/ but not before 'voiced' fricatives /v, z, ɣ/. There have been numerous proposals to account for this asymmetry in Dutch, typically consisting of a progressive (devoicing) assimilation rule (e.g. Booij 1995:58-59, Wetzels & Mascaró 2001) and/or a fricative devoicing rule (e.g. Zonneveld 2007). Iverson & Salmons (2003b) argue that after syllable-final devoicing in Dutch (see below), the laryngeal specification of post-obstruent fricatives is neutralized, followed by enhancement with [spr gl] via Vaux's Law (Section 2.9). Phonetic and phonological accounts of Dutch RVA will be discussed in more detail below.

This chapter explores phonetic implementation further by presenting experimental acoustic data from Dutch stops and fricatives, focusing mainly on obstruent duration, voicing duration during closure, and VOT (as for Norwegian in Chapter 3), and also examines stops and fricatives in word-initial obstruent + sonorant clusters as well as word-internal obstruent + obstruent clusters. Based on observations by Iverson & Salmons (2003b) and van Oostendorp (2007), for example, that the differences in the phonetic and phonological behavior of Dutch stops and fricatives suggest a hybrid system where stops and fricatives have a different laryngeal contrast, further instrumental investigation of these differences is called for.

While the asymmetry between stops and fricatives in terms of Dutch RVA has been demonstrated in numerous studies, a promising area to investigate further is whether there are differences between stops and fricatives in the degree of sonorant devoicing; if Dutch truly is a mixed system with [voice] contrastive for stops and [spr gl] contrastive for fricatives, then we might expect to see more sonorant devoicing after voiceless ([spr gl]) fricatives than voiceless (unspecified) stops. This chapter is meant to fill that gap by directly comparing stops and fricatives in obstruent-sonorant clusters and obstruent-obstruent assimilation environments. However, as the results of other experiments (discussed below) as well as the experiments presented in this chapter show, the phonetic reality is far more complex than the standard phonological accounts seem to imply. This chapter proceeds as follows: Following a brief discussion of a few relevant sound changes in the development of modern Dutch, I examine modern Dutch phonetics and phonology, including a discussion of some phonological processes and a review of some phonetic studies. I then present the data and results from my own experiments of Dutch, followed by a phonological analysis and a conclusion.

4.2. Diachronic background

Most of the historical developments relevant to Dutch were discussed in Section 1.2, though a few additional remarks are in order here. As mentioned in Section 1.2.6, the PGmc stops *p, *t, *k inherited by WGmc remain unchanged in WGmc (with the exception of High German dialects; see Chapter 5), including modern Dutch, and require no further discussion here. As also discussed, PGmc *d lost its spirantized allophone *ð in all positions throughout WGmc[55] while *b was a stop initially, following sonorants, and in gemination, but was a spirant elsewhere. Gussenhoven & Bremer (1983:56) add that in intervocalic position, the spirant allophone of WGmc *b has become /v/ in modern Dutch. Finally, Gussenhoven & Bremer (1983:59) state that modern Dutch /ɣ/ “derives from initial and intervocalic [WGmc] /g/…as well as from

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[55] Robert Howell (p.c.) notes that PGmc *ð was likely retained and then lost intervocalically in western Dutch.

(intervocalic) geminated /g/…, which is assumed to have become a fricative after the [Middle Dutch] period"; this implies that WGmc *g lost its spirant allophone in earlier stages of Dutch, but it later became a fricative in all positions (except after a nasal).

The development of the PGmc/WGmc fricatives *f, *þ, *s, *h is somewhat more complex than that of the stops as a result of the so-called *Spirantenschwächung* or 'spirant lenition' (see e.g. Braune 2004, Paul 2007). As explained in Section 1.2.6, *þ became voiced and subsequently occluded to /d/ throughout most of WGmc, including Dutch (Braune 2004:162-167). Gussenhoven & Bremer (1983:56-57) state that WGmc (singleton) *f became voiced in non-final positions by Middle Dutch, though there were apparently a few exceptions, and loanwords from Old French with initial /f/ created the conditions for a phonemic contrast to develop word-initially; in medial position, voiced *f merged with spirantized *b to become /v/, and a medial contrast developed when geminate *f became degeminated. Gussenhoven & Bremer (1983:57-58) give a similar story for *s as that of *f in Dutch, namely widespread non-final voicing; however, *s was retained as voiceless /s/ in clusters other than *sw- > /zʋ-/; loanwords and, presumably, degemination of medial geminate *s have led to a non-final /z/~/s/ contrast along the same lines as the /v/~/f/ contrast in modern Dutch. Finally, Gussenhoven & Bremer (1983:59-60) note that WGmc *h has been retained in Dutch as /x/ word-finally and in word-medial geminates (subsequently degeminated) where a contrast with /ɣ/ developed, and that a word-initial opposition between /x/ and /ɣ/ developed with the introduction of loanwords such as *chaos* and *chloor* 'chlorine'; recall that as elsewhere in Germanic, *h was lost word-initially before consonants (sonorants) and word-medially in a voiced environment.

In summary, then, the main change to the stops was the spirantization of *g > /ɣ/,[56] and the main change to the fricatives was the widespread voicing of *f > /v/ and *s > /z/ in many non-final environments (all obstruents are devoiced word-finally; more on this below). Thus Dutch developed voicing contrasts for all fricatives: /f/~/v/, /s/~/z/, and /x/~/ɣ/, with the last pair due to the retention of /x/ in some environments and the spirantization of *g > /ɣ/, and in all cases partially due to the introduction of loanwords.[57]

4.3. Modern Dutch phonetics and phonology

4.3.1. Obstruents

According to Booij (1995:7), the consonant inventory of Dutch is as follows:

	bilabial	labio-dental	alveolar	palatal	velar	glottal
plosives	p, b		t, d		k, (g)	
fricatives		f, v	s, z		x, ɣ	h
nasals	m		n		ŋ	
liquids			l, r			
glides		ʋ		j		

Table 4.1 Dutch consonant inventory

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[56] Robert Howell (p.c.) knows of no evidence that WGmc *g was ever a stop in any position in Dutch and has thus likely been a spirant all along.

[57] Robert Howell (p.c.) points out that the development of Dutch can be seen as the result of contact between Ingvæonic (North Sea Gmc) speakers in the western coastal areas and Franconian speakers from the east; there is therefore a bundle of east-west isoglosses running from north to south. Additionally, there are north-south differences resulting both from contact with Romance dialects in the south and, later, large numbers of Franconian speaking immigrants (from the east) in the north in the 16th and 17th centuries. This may explain some of the variation discussed in this chapter.

Booij (1995:7) explains that [g] only appears in non-native words (e.g. *goal*) and as the voiced allophone of /k/ (e.g. *zakdoek* [zɑgduk] 'handkerchief'). As noted above, WGmc *g became occluded in many environments along with the other lenis stops but later became spirantized in Middle Dutch; it is now realized as a velar fricative (or post-palatal in the southern Netherlands and Dutch-speaking Belgium or uvular in Western Dutch; Booij 1995:8) though it is still represented orthographically as <g>. As for the remaining stops, /b, d/ are described as 'voiced' and /p, t, k/ are described as 'voiceless unaspirated'. However, Jansen (2007:130) states that /p, t, k/ are aspirated in the province of Groningen (the northeastern-most province of the Netherlands); furthermore, Blancquaert (1962) finds devoicing of initial /b, d/ in the northern Netherlands. Thus some northern dialects of Dutch may have a voiceless/voiceless aspirated contrast in the stops, similar to other Germanic languages.

Slis & Cohen (1969) find eight phonetic cues related to the voiced-voiceless distinction in intervocalic Dutch obstruents, only one of which is vocal fold vibration (as summarized in Slis 1970:193):

1) consonant duration
2) duration of the preceding vowel
3) duration and spectral extensiveness of the vowel formant transitions
4) presence or absence of vocal fold vibration
5) duration of the noise burst of stops
6) sound pressure of the noise burst of stops, friction noise of fricatives
7) sound pressure of the adjacent vowels

8) peak value of the fundamental frequency of the surrounding vowels and the contour of the fundamental frequency during the following vowel

Thus phonetic implementation of phonological [voice] can involve much more than vocal fold vibration. Moreover, Slis (1970) finds that in addition to the expected vocal fold vibration during voiced obstruents in Dutch, voiceless obstruents are accompanied by a glottal opening gesture. His study also finds that the closure duration of voiceless stops is longer than voiced stops (1970:202). Furthermore, Löfqvist et al. (1989) find a statistically significant difference in cricothyroid muscle (the muscle responsible for the longitudinal tension of the vocal folds) activity between voiced and voiceless obstruents in Dutch; specifically, there is increased activity during the production of voiceless obstruents, meaning that vocal fold vibration is being actively inhibited.

Simon (2010:12) notes that "[i]n Dutch, a sonorant is usually not devoiced when following an obstruent, since, just as aspiration, sonorant consonant devoicing in English is the result of the wide open glottis during the production of the obstruent. As the glottal opening during the production of Dutch obstruents is smaller, no devoicing occurs in Dutch obstruent + sonorant consonant clusters." However, while Simon's results for VOT in Belgian Dutch /p, t, k/ are similar to other studies (/p/ 12 ms, /t/ 23 ms, /k/ 29 ms; 2010:78), her results also show increased VOT in stop + sonorant clusters (2010:80):

1)

Cluster:	VOT (in ms):
/tr/	37
/kl/	49
/kr/	45

/pl/	24
/pr/	24
mean	36

Simon (2010:83) also says that in her study, 93% of tokens with word-initial /b, d/ were produced with prevoicing.

Concerning the fricatives, Booij mentions (1995:7-8) that the voiced/voiceless distinction between the fricatives /f/~/v/ and /x/~/ɣ/ is neutralized to the voiceless variant word-initially and often word-medially in the western part of Holland. As pointed out by numerous authors (Gussenhoven & Bremmer 1983; Van de Velde et al. 1997; Van de Velde & van Hout 2001; Kissine et al. 2003, 2005; etc.), all word-initial fricatives (including /z/) are generally pronounced voiceless, especially in the northern and western varieties of Dutch, but word-medial fricatives are also often devoiced, particularly /ɣ/ → [x].[58] In fact, Gussenhoven & Bremmer (1983:60-61) state that /ɣ/ is realized as voiceless [x] in all environments in their data. Slis & Van Heugten (1989) examine intervocalic fricative voicing in western and southeastern Dutch and find that in western varieties, only 20% of /v/ and /z/ tokens are voiced and less than 6% of /ɣ/; in the southeastern varieties, only 25% of /v/ and /z/ are voiced and approximately 31% of /ɣ/; finally, they find that while /f/, /s/, and /x/ are consistently voiceless, they are also 40-50 ms longer than their counterparts /v/, /z/, and /ɣ/. In the transillumination portion of his study, Slis finds that the peak glottal opening is 50% larger for voiceless fricatives than for voiceless stops (1970:198), which means that in addition to a general lack of voicing in voiced fricatives,

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[58] Robert Howell (p.c.) notes that there was confusion between the graphemes <f> and <v> as early as the 17th century in northern Dutch, which suggests devoicing of /v/ may have begun around that time.

voiceless fricatives are produced with an active glottal spreading gesture in Dutch (via Vaux's Law; Vaux 1998, Avery & Idsardi 2001).

In Pinget's (2015) recent study of voicing in labiodental fricatives and labial stops in five different Dutch-speaking areas in the Netherlands and Flanders, she finds that /v/ is shorter than /f/ (116 ms vs. 147 ms) and more voiced (43.6% vs. 15.6%) and that /b/ is also shorter than /p/ (102 ms vs. 136 ms) and more voiced (75.8% vs. 14.9%) (2015:46). She also finds regional differences, with more voicing of /v/ in Flanders and less in the Netherlands, with Groningen in the northern Netherlands showing very little voicing, and a nearly inverse difference in duration (2015:49-51). However, her results for /b/ show only minor differences in duration and no statistically significant differences in voicing across regions (2015:51-53). She also finds a good deal of inter-speaker variation in voicing for both /v/ and /b/, with many speakers using both voicing and duration to mark the distinction, and a strong correlation between fricative devoicing and stop devoicing (2015:53-56). The basic premise of her study is that fricative devoicing is in the advanced stages of sound change while stop devoicing is an incipient sound change (2015:29, 30); her perception (2015:61-92) and sociolinguistic (2015:93-132) experiments support this analysis.

As noted above, in addition to an active voicing gesture for voiced obstruents, there also appears to be an active glottal spreading gesture as well as active inhibition of vocal fold vibration for voiceless obstruents. However, in spite of the presence of active voicing as well as active devoicing gestures, the standard phonological analysis of Dutch is that [voice] (either binary or privative) is the relevant distinctive feature as opposed to [spr gl] due to the presence of prevoicing in /b/ and /d/ as well as the ability of these segments to trigger RVA, and the general absence of aspiration on /p, t, k/ (Iverson & Salmons 1995, 2003a, b; Booij 1995, and many others).

Regardless of what is going on phonologically, the experimental phonetic evidence above shows that both voicing and devoicing gestures are present at the phonetic level in Dutch. However, in spite of Slis's (1970) findings that a glottal spreading gesture occurs in voiceless obstruents in Dutch, Lisker & Abramson show only short-lag VOT (10-30 ms) for Dutch /p, t, k/ (1964:392, 409) compared to the long-lag VOT (50-80 ms) reported for Swedish /p, t, k/ by Helgason & Ringen 2008:613); apparently the degree of glottal opening (Kim 1970) is different for Dutch and Swedish, so there is at least a phonetic difference between the glottal spreading gestures of the two languages. On the other hand, prevoicing duration is very similar in Dutch and Swedish: prevoicing duration for male speakers is 109 ms in both languages, but it is slightly longer for female Dutch speakers (89 ms) than female Swedish speakers (66 ms) (Helgason & Ringen 2008:612, van Alphen & Smits 2004:463).[59] However, van Alphen & Smits also note that 25% of the LENIS stops in their study lacked prevoicing, with one speaker producing only 38% of LENIS stops with prevoicing, and nearly 10% of the LENIS stops in the perception portion of their study were mistakenly perceived as FORTIS due to a lack of prevoicing in most of these cases (2004:462, 481).

In spite of the presence of vocal fold vibration in both Dutch and Swedish LENIS stops, they are often labeled 'voicing' and 'aspirating' languages, respectively, due to the differences in

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[59] These are the results for the first experiment conducted by van Alphen & Smits; the results for the second experiment are lower, and they are pooled across both genders: 82.80 ms for /b/ and 71.23 ms for /d/ (2004:470).

aspiration of the FORTIS stops. As noted in Section 2.11, Hall's (2011) model of contrast and enhancement allows for this type of phonetic overdifferentiation; if one series is underlyingly either [voice] or [spr gl], the other series can be phonetically enhanced with a devoicing or voicing gesture, respectively, to enhance the contrast between the two series. Phonological activity such as assimilation reveals which gesture is phonologically specified and which is a phonetic enhancement; in Dutch, [voice] appears to be phonologically active (in RVA) while in Swedish, [spr gl] appears to be phonologically active (Helgason & Ringen 2008 point out that clusters always assimilate to voicelessness in Swedish).

4.3.2. Phonology and phonetics of RVA

Menert (1994:4-9, based on Trommelen & Zonneveld 1979) summarizes RVA with the following set of rules (see also Booij 1995:57-64 or Zonneveld 2007):

2) i. Final Devoicing: word-final voiced stops become voiceless

[-son] → [-voice]/_______#

ex. *hand* [-t] 'hand'; *handen* [-d-] 'hands' (Zonneveld 2007:3)

Note that many authors, e.g. Zonneveld (2007:2, 4-5), state this rule as syllable-final devoicing ([-son] → [-voice]/_______$) based on examples such as *kidnap* [-t.n-]

ii. Progressive Assimilation: voiced fricatives become devoiced following voiceless (or devoiced by rule i.) obstruents

[-son, +cont] → [-voice]/[-voice](#)_______

ex. *drijfzand* [-f.s-] 'quicksand' (Zonneveld 2007:3)

iii. Regressive Assimilation: obstruents take on the voicing character of whatever obstruent immediately follows

$[-\text{son}] \rightarrow [\alpha\ \text{voice}] / \_\_\_\_\_\_\_ (\#)[-\text{son}, \alpha\ \text{voice}]$

ex. *stropdas* [-b.d-] ‘necktie’ (Zonneveld 2007:3)

zout brant [-d b-] ‘salt burns’ (Menert 1994:31)

iv. Consonant Degemination: a sequence of two identical obstruents (which can be due to assimilation) reduces to one

$[+\text{cons}]_i\ (\#)\ [+\text{cons}]_i \rightarrow [+\text{cont}]_i$

ex. *schrijf vrede* [sχrɛifredə] ‘write peace’ (Menert 1994:7)

According to these rules, Final Devoicing, which affects all obstruents, feeds Progressive Assimilation, which only affects fricatives; at this point, the effects of Regressive Assimilation will go unnoticed unless the following obstruent is a LENIS stop, in which case Regressive Assimilation reverses the effects of Final Devoicing and the preceding obstruent becomes voiced. If the result of any of these rules is a sequence of two identical obstruents, Consonant Degemination reduces them to one. Numerous non-linear accounts of Dutch RVA have been proposed, such as Lombardi (1991, 1995), Ernestus (2000), Grijzenhout (2001), and Zonneveld (2007), but these rules provide the basics of the phonological processes involved; most phonological accounts seem to base their analyses on some form of these rules, though the ordering may be different.

Iverson & Salmons (2003b) offer an alternative approach to the asymmetry between LENIS stops and fricatives, arguing that Dutch FORTIS fricatives have retained their phonological [spr gl] specification from Germanic (due to Vaux’s Law, discussed in Chapter 2) while the LENIS stops and fricatives have acquired [voice] through contact with Romance dialects. As a result, the fricatives have become overspecified with both [spr gl] and [voice], even though only one series needs to be marked. To account for the RVA asymmetry, they posit a rule that neutralizes the laryngeal specification of post-obstruent fricatives, which follows the well-known rule of syllable-final devoicing in Dutch; thus the preceding obstruent is always voiceless, and the neutralized fricative that follows is then enhanced with [spr gl] via Vaux's Law, resulting in a completely voiceless obstruent-fricative cluster even if both segments are underlyingly [voice].

Phonetic accounts of Dutch RVA show that the situation is more complex than the standard phonological accounts indicate. Van Dommelen (1983) examines fricative-stop clusters in Dutch and finds that in word-internal /fm/ and /sm/ clusters, the /m/ is partially devoiced. However, he also finds that in /fb/ clusters in compound words, /b/ is (partially) voiced in only 11 out of 100 tokens and in /sd/ clusters, /d/ is (partially) voiced in only 20 out of 100 tokens. Instead of a difference in vocal fold vibration, the main differences are the duration of the preceding vowel (longer before /b, d/ than /p, t/), the VoffT of the fricative (slightly longer before /b, d/ than /p, t/), and the duration of the fricative (shorter before /b, d/ than /p, t/). He states:

> [I]n most cases in fortis + lenis clusters, regressive *voicing* does not take place. Rather, a process of "lenition" is found, in that the first syllable is temporally reorganised: in the clusters with /fb/ and especially /sd/ (but not /fm/ or /sm/) a lengthened vowel and/or shortened fricative were found. A more or less voiced fricative was spoken in relatively few cases. (1983:54; van Dommelen's emphasis)

These results indicate that although assimilation may be taking place, the phonetic realization typically does not involve much vocal fold vibration in either segment, but rather is manifested by temporal changes.

Slis (1986) examines assimilations across word and morpheme boundaries, with a comparison of assimilation before and after a stressed syllable across word boundaries (apparently there are so few examples of disyllabic words with stress on the second syllable where assimilation might occur that it is not worth investigating). In his study, C1 is a voiceless obstruent /p, t, k, f, s, x/ and C2 is either /b/ or /d/. He finds three different conditions: regressive (voice) assimilation, no assimilation, and progressive (devoicing) assimilation. He judges RVA to have occurred if C1 has more than 50 ms of glottal pulsing and C2 is prevoiced, no assimilation has occurred if C1 has less than 50 ms of glottal pulsing and C2 is prevoiced, and progressive assimilation has occurred if C1 has less than 50 ms of glottal pulsing and C2 has a positive VOT (i.e. no prevoicing). His results for stop-stop clusters are as follows (Slis 1986:317):

3) Instances of RVA (C1 voicing tail > 50 ms, C2 prevoicing):

across word boundaries before stress: 103 out of 120 tokens

across word boundaries after stress: 24 out of 120 tokens

word-internally after stress: 60 out of 120 tokens

Instances of no assimilation (C1 voicing tail < 50 ms, C2 prevoicing):

across word boundaries before stress: 4 out of 120 tokens

across word boundaries after stress: 35 out of 120 tokens

word-internally after stress: 9 out of 120 tokens

Instances of progressive devoicing (C1 voicing tail < 50 ms, C2 no prevoicing)

across word boundaries before stress: 13 out of 120 tokens

across word boundaries after stress: 61 out of 120 tokens

word-internally after stress: 51 out of 120 tokens

The results for fricative-stop clusters are as follows (Slis 1986:317):

4) Instances of RVA (C1 voicing tail > 50 ms, C2 prevoicing):

across word boundaries before stress: 43 out of 120 tokens

across word boundaries after stress: 14 out of 120 tokens

word-internally after stress: 34 out of 120 tokens

Instances of no assimilation (C1 voicing tail < 50 ms, C2 prevoicing):

across word boundaries before stress: 39 out of 120 tokens

across word boundaries after stress: 35 out of 120 tokens

word-internally after stress: 32 out of 120 tokens

Instances of progressive devoicing (C1 voicing tail < 50 ms, C2 no prevoicing)

across word boundaries before stress: 38 out of 120 tokens

across word boundaries after stress: 71 out of 120 tokens

word-internally after stress: 54 out of 120 tokens

These results show that fricatives are more resistant to RVA than stops, but the only category that regularly undergoes RVA is stop-stop clusters across word boundaries before a stressed syllable (103 out of 120 tokens, or about 86%). Word-internally (i.e. in post-stress position), stop-stop clusters undergo RVA only 50% of the time (60/120 tokens) while over 40% of the tokens (51/120) are completely voiceless (aside from a short voicing tail). Furthermore, Slis's results also show that for both stop-stop and fricative-stop clusters, the total cluster durations are shorter when RVA occurs (1986:318). However, in spite of the durational differences observed between assimilated and non-assimilated clusters, the results of the perception portion of his experiment show that far more tokens are perceived to exhibit RVA than was expected based on the voicing results in the production experiment (for word-internal clusters, 505/640 tokens, or about 79%, were perceived as having RVA; 1986:321), which means listeners are evidently relying on cues other than phonetic voicing or cluster duration in determining whether RVA is occurring.

Jansen (2007) conducts experiments on assimilation across word boundaries in Dutch, specifically in word-final stop-fricative /-ps#/ clusters followed by either a voiceless stop /p, t/, a voiced stop /b, d/, a sonorant /m/, a glottal fricative /h/, or a vowel /V/ (which is preceded by a glottal stop [ʔ], yielding essentially a /ps#ʔ/ cluster), and in each case with primary stress on the following syllable (the conditions under which Slis 1986 finds RVA most likely to occur). In these C1C2C3 clusters, Jansen's results show that the voice tail of C1 (/p/) is roughly the same (ca. 20 ms) when C3 is /p, t/, /h/, or /V/, but that the voice tail increases to 29 ms when C3 is /m/ and increases again to 32 ms when C3 is /b, d/; similarly, voicing at the end of C2 (/s/) is the same (ca. 1 ms) when C3 is /p, t/, /h/, or /V/, but increases to 5 ms before /m/ and to 16 ms before /b, d/. His results also show that the duration of C1 /p/ varies very little, whereas the duration of C2 /s/ varies according to the identity of C3; /s/ is longer before /p, t/ (85 ms), shorter before /b, d/ (67 ms), and the duration before /m/ is somewhere in between (79 ms). In these results, /m/ shows some signs of inducing RVA, falling somewhere between /p, t/ and /b, d/, even though it is argued to be laryngeally unspecified. (Compare van Dommelen's (1983) results above that show partial devoicing of /m/ after fricatives.) Jansen argues on the basis of this (and other) evidence that Dutch RVA is a low-level coarticulatory process, similar to the argument made by Ernestus (2000). Slis (1986), Ernestus (2000), and Jansen (2007) argue that Dutch RVA is an optional process that is clearly sensitive to stress and prosodic boundaries.

There is also at least some variation in the extent to which different varieties of Dutch exhibit RVA. Simon (2010:126) reports that in her study of RVA across word boundaries in Belgian Dutch, “89% of the voiceless stops became voiced when preceding a voiced stop” and when stops and fricatives are pooled together, 92% of all voiceless obstruent + voiced stop clusters were produced as voiced; however, the asymmetry also holds in Belgian Dutch, with 93% of obstruent + ‘voiced’ fricative (partially voiced in her data; 2010:97) clusters being realized as voiceless (2010:164). On the other hand, Grijzenhout (2001:16) states the following about Randstad Dutch:

> In Randstad Dutch (roughly, the version of modern Dutch spoken in western cities, e.g., Rotterdam, Den Haag, Leiden, Gouda, Delft), there is no regressive voicing assimilation in clusters of a prosodic word-final voiceless obstruent plus prosodic word-initial voiced plosive.

She provides the following examples from Randstad Dutch (2001:16):

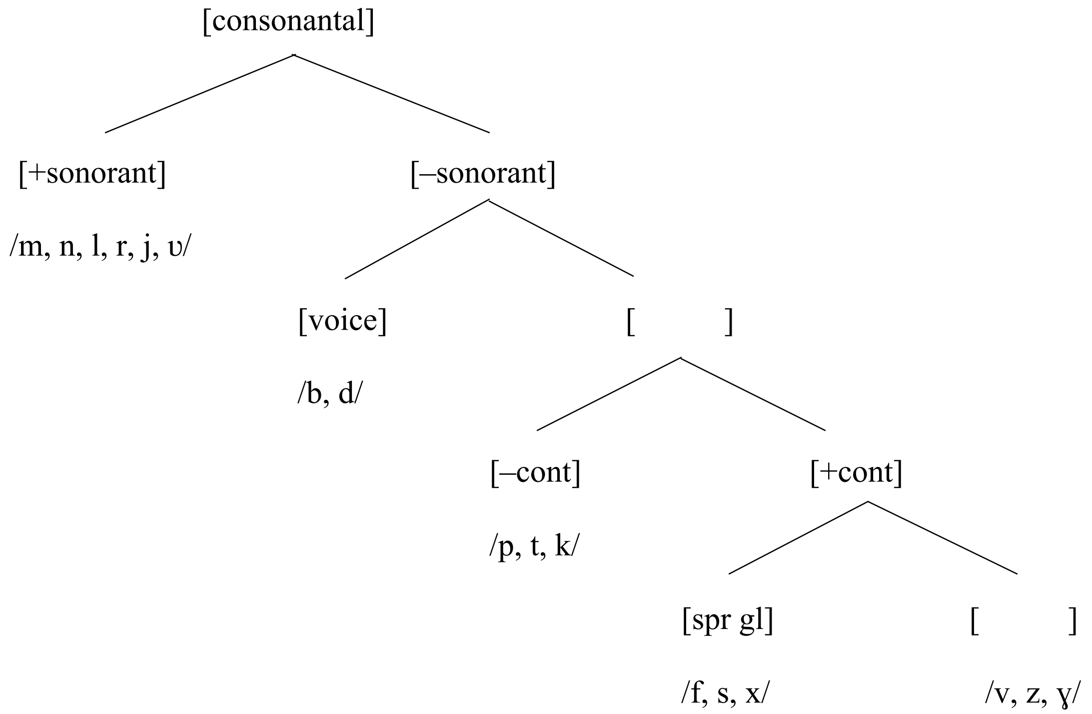
5)	bewij/z/ + /b/aar	bewij[s.b]aar	‘provable’
	za/k/ + /d/oek	za[k.d]oek	‘handkerchief’
	raa/d/ + /z/aam	raa[t.s]aam	‘advisable’

The realization of the medial cluster in *raadzaam* as voiceless is the same as elsewhere in Dutch because LENIS fricatives apparently do not induce RVA in any dialect, but evidently in this dialect, /b/ and /d/ also fail to induce RVA.

4.3.3. Preliminary analysis

Based on the standard account of Dutch, namely that /b, d/ are realized as voiced and trigger RVA, /v, z, ɣ/ are generally realized as voiceless and fail to trigger RVA, and /p, t, k, f, s, x/ are voiceless and undergo RVA, the following contrastive hierarchy for Dutch can be posited as a first pass (to be developed below):

6)



This hierarchy accounts for several things at once. First of all, /b, d/ contrast with /p, t, k/ (and all fricatives) by virtue of the feature [voice] and /f, s, x/ contrast with /v, z, ɣ/ by virtue of the feature [spr gl]; this also explains the presence of phonetic voicing for /b, d/ and the general lack thereof for /v, z, ɣ/. Additionally, /b, d/ are the only obstruents to trigger RVA because they are the only obstruents specified as [voice]; /v, z, ɣ/ fail to trigger RVA because they are laryngeally unspecified. At the same time, /p, t, k/ undergo RVA because they are laryngeally unspecified and /f, s, x/ undergo RVA even though they are specified as [spr gl] because [voice] is ordered above [spr gl]. Finally, this allows for the possible phonetic enhancement of /p, t, k/ with [spr gl] as well as the phonetic enhancement of /v, z, ɣ/ with [voice], and both aspirated /p, t, k/ and partially voiced /v, z, ɣ/ are reported in the literature for Dutch, as noted above. This hierarchy therefore accounts for the phonetic and phonological behavior of Dutch obstruents in the standard descriptions in the literature. However, as we have seen, the situation is rather complex in terms of phonetic implementation, and we also lack any concrete evidence that /f, s, x/ are underlyingly specified for [spr gl]; the presence of Final Devoicing makes it impossible to determine if [spr gl] is spreading in clusters. The remainder of this chapter explores these questions further.

4.4. Experimental data

4.4.1. Methodology

Data were collected from 8 speakers, 3 female and 5 male. Subjects ranged in age from approximately 20 to 60 years old and came from the Randstad area of the western Netherlands (6 from South Holland (Rotterdam), 1 who had grown up in both Rotterdam and Amsterdam, and 1 from Utrecht). In light of Grijzenhout's (2001) claim that RVA does not occur in Randstad Dutch, this presents an opportunity to test that claim. As with Norwegian in Chapter 3, the subjects were not recorded in a sound-proof booth, and most of them were recorded in their homes or a similar casual setting.

The main difference between the speakers was the realization of /r/, which was typically an alveolar flap or trill for the Rotterdam speakers and a uvular trill or fricative for the remaining speakers. Schwa epenthesis sometimes occurred, mainly before /r/ when it was realized as an alveolar or uvular tap or trill.

Similar to the Norwegian experiment in the previous chapter, the Dutch speakers in this study were asked to read a list of 110 real Dutch words embedded in a carrier phrase (*kunt u* _______ *voor mij zeggen?* ‘could you say _______ for me?’). 80 of the words were target words and the remaining words were distractors, some of which were used for the assimilation portion of the experiment. Each target word consisted of a word-initial bare stop or fricative, or obstruent-sonorant cluster, followed by a short vowel in most cases, and that vowel was then followed by a voiceless obstruent in most cases; most target words were also disyllabic.

Because /g/ and word-initial /x/ (<ch>) only occur in a few loanwords, these phonemes were not included in the word list. However, as noted by Gussenhoven & Bremer (1983), /ɣ/ (<g>) is consistently realized as voiceless [x] in their data, which it also is in mine; I therefore use the phonetic transcription [x] for <g> in the results below (for simplicity, even though it may also be realized as uvular [χ]) instead of the phonemic symbol /ɣ/. I also group it with the FORTIS fricatives /f, s/ since it generally patterns with them. Additionally, the phoneme /ʋ/ is described by Booij (1995:8) as a “labiodental approximant”, but van der Torre (2003:181-204) notes that it exhibits both sonorant and fricative properties, similar to Norwegian /ʋ/ in the previous chapter as well as /ʋ/ in numerous other languages; /ʋ/ is treated as both a sonorant and a fricative in the results below. The full word list is provided in Appendix B.

4.5. Results

4.5.1. Stops

4.5.1.1. Closure duration

Closure duration in ms for bare stops and stop-sonorant clusters:

		bare	/l/	/n/	/r/	/ʋ/
b		/b-/	/bl-/		/br-/	
	mean	108.97	94.79		93.13	
	st. dev.	23.36	19.03		19.95	
p		/p-/	/pl-/		/pr-/	
	mean	123.74	111.00		105.45	
	st. dev.	24.62	23.38		30.43	
d		/d-/			/dr-/	/dʋ-/
	mean	92.33			83.09	76.34
	st. dev.	23.19			16.33	20.73
t		/t-/			/tr-/	/tʋ-/
	mean	109.13			89.41	80.90
	st. dev.	19.42			24.36	17.08
k		/k-/	/kl-/	/kn-/	/kr-/	/kʋ-/
	mean	100.32	91.75	82.71	87.23	91.06
	st. dev.	24.20	15.77	12.56	18.49	24.07

Table 4.2 Results for mean closure duration in ms for bare stops and stop-sonorant clusters

Dutch FORTIS stops are longer in duration than LENIS stops, with some differences in place of articulation, and we also see a decrease in closure duration in stop-sonorant clusters. A two-way ANOVA was run, with voicing and place of articulation (excluding velar, due to lack of /g/) as independent variables, with the following results:

LENIS/FORTIS	F (1, 107) = 13.35	$p = 0.0004$	omega^2 = 0.09
Place	F (1, 107) = 13.08	$p = 0.0005$	omega^2 = 0.09
Both	F (1, 107) = 0.00	-	-

Table 4.3 Two-way ANOVA for closure duration

There is a main effect for both voicing and place, but no interaction, thus the differences in duration between LENIS and FORTIS as well as place of articulation are statistically significant.

4.5.1.2. VoffT (pulsing duration)

VoffT for bare stops:

LENIS	mean VoffT in ms	s.d.	FORTIS	mean VoffT in ms	s.d.
/b-/	66.38	35.21	/p-/	23.88	21.29
/d-/	52.86	29.61	/t-/	16.82	13.43
			/k-/	14.20	11.82
pooled	59.62	32.97	pooled	18.40	16.48

Table 4.4 Results for mean VoffT in ms in bare stops

Some speakers had a tendency to pause briefly before uttering the target word; when this occurred before LENIS stops (13 occurrences), there was no prevoicing in most of these cases, and they are not included in these results.[60] By way of comparison, van Alphen & Smits' study of Dutch (2004:470) reports 82.80 ms of prevoicing for /b/ (s.d. 54.00) and 72.23 ms for /d/ (s.d. 54.53), which is much higher than the pulsing durations reported here, though they do not report closure durations in their study.

Two-way ANOVA (excluding velar):

LENIS/FORTIS	F (1, 106) = 57.38	$p < 0.0001$	omega^2 = 0.34
Place	F (1, 106) = 3.94	$p = 0.0497$	omega^2 = 0.02
Both	F (1, 106) = 0	-	-

Table 4.5 Two-way ANOVA for VoffT

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[60] Van Alphen & Smits note that in their study, one speaker produced only 38% of LENIS stops with prevoicing (2004:462).

Here we see a main effect for LENIS/FORTIS and for place, but the effect size for place is quite small. In this case, we see a much larger effect size for LENIS/FORTIS than for closure duration above, meaning there is a stronger correlation between the LENIS/FORTIS distinction and pulsing duration than closure duration.

Generally speaking, VoffT is much the same in stop-sonorant clusters:

LENIS	mean VoffT in ms	s.d.	FORTIS	mean VoffT in ms	s.d.
/bl-/	67.86	33.53	/pl-/	20.30	14.51
/br-/	75.52	33.37	/pr-/	22.48	14.24
/dr-/	61.29	28.75	/tr-/	15.76	10.77
/dʋ-/	47.31	23.58	/tʋ-/	13.45	9.27
			/kl-/	14.86	13.84
			/kn-/	14.13	11.36
			/kr-/	15.35	10.00
			/kʋ-/	16.53	11.99

Table 4.6 Results for mean VoffT in ms in stop-sonorant clusters

Figures 4.1 and 4.2 show /b/ with no prevoicing and /b/ with prevoicing, from the same speaker:

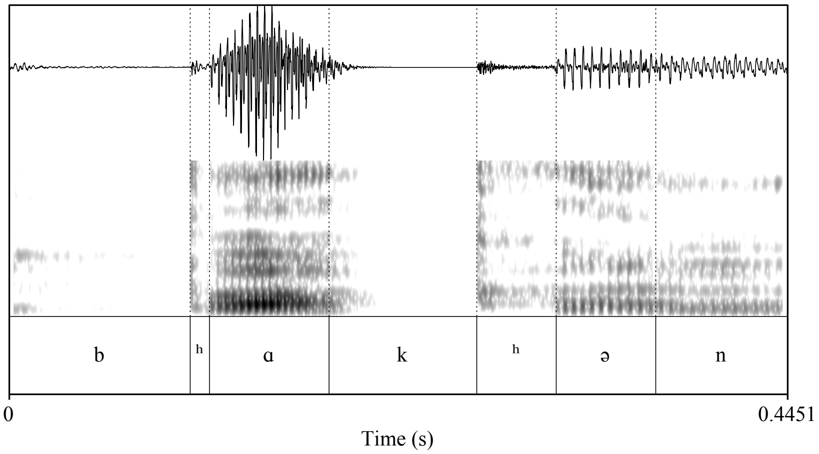

Figure 4.1 Token of *bakken* ‘to bake’ from speaker F1, with a short voicing tail but no prevoicing

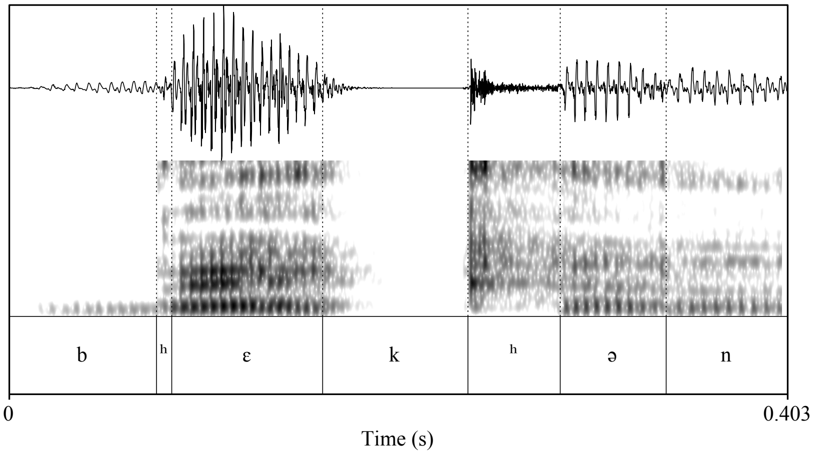

Figure 4.2 Token of *bekken* ‘basin’ also from speaker F1, with prevoicing

4.5.1.3. % glottal pulsing

% glottal pulsing for bare stops:

LENIS	mean % pulsing	s.d.	FORTIS	mean % pulsing	s.d.
/b-/	64.18	35.39	/p-/	19.31	16.54
/d-/	59.90	34.41	/t-/	16.21	14.17
			/k-/	15.41	12.21
pooled	62.04	34.68	pooled	17.51	14.26

Table 4.7 Results for mean % glottal pulsing in bare stops

LENIS stops exhibit large standard deviations, which may be due to the tendency of some speakers to pause briefly before uttering the target word. Tokens with a clear pause were excluded for this measure, but this tendency may have affected other tokens. Since there is no glottal pulsing in these cases, LENIS stops can range from 0-100% glottal pulsing (0%: 6/78 tokens; 100%: 27/78 tokens).

Two-way ANOVA (excluding velar):

LENIS/FORTIS	F (1, 106) = 67.98	$p < 0.0001$	omega^2 = 0.40
Place	F (1, 106) = 0.47	$p = 0.4932$	n.s.
Both	F (1, 106) = 0	-	-

Table 4.8 Two-way ANOVA for % glottal pulsing

Here we see a main effect for LENIS/FORTIS only, and also a reasonably large effect size. The differences between place of articulation in Table 4.7 above are quite small, so the ANOVA results for place are not surprising.

There is little difference in % glottal pulsing in stop-sonorant clusters compared to bare stops above:

LENIS	mean % pulsing	s.d.	FORTIS	mean % pulsing	s.d.
/bl-/	72.52	34.14	/pl-/	18.41	13.80
/br-/	80.77	29.42	/pr-/	21.52	14.57
/dr-/	74.13	32.28	/tr-/	17.52	13.92
/dʋ-/	65.31	33.59	/tʋ-/	16.35	11.34
			/kl-/	15.63	14.14
			/kn-/	16.85	13.24
			/kr-/	17.78	11.80
			/kʋ-/	18.28	14.17

Table 4.9 Results for mean % glottal pulsing in stop-sonorant clusters

4.5.1.4. VOT

This section deals with positive VOT, or voicing lag, only; voicing lead in Dutch has been covered extensively in other studies (Lisker & Abramson 1964, van Alphen & Smits 2004, etc.) and the stops in this experiment are in a postvocalic environment. The results for VoffT above cover cases of negative VOT. However, some clear cases of voicing lead will be discussed below.

VOT for bare stops:

LENIS	mean VOT in ms	s.d.	FORTIS	mean VOT in ms	s.d.
/b-/	14.44	5.18	/p-/	17.45	5.80
/d-/	21.41	6.42	/t-/	29.70	9.97
			/k-/	39.49	11.12
pooled	17.93	6.77	pooled	28.87	12.91

Table 4.10 Results for mean VOT in ms in bare stops

Mean VOT for Dutch /p/ is only slightly higher than /b/ while there is a greater difference between /t/ and /d/. These results are quite similar to those reported by van Alphen & Smits for Dutch labial and alveolar stops, with only a few milliseconds difference (2004:471, 476):

LENIS	mean VOT in ms	s.d.	FORTIS	mean VOT in ms	s.d.
/b-/	11.55	7.56	/p-/	18.91	11.82
/d-/	18.52	10.31	/t-/	31.39	17.50
pooled	15.1	-	pooled	25.1	-

Table 4.11 Van Alphen & Smits' results for mean VOT in ms

Two-way ANOVA (excluding velar):

LENIS/FORTIS	F (1, 123) = 20.30	$p < 0.0001$	omega^2 = 0.09
Place	F (1, 123) = 58.75	$p < 0.0001$	omega^2 = 0.28
Both	F (1, 123) = 3.46	$p = 0.0651$	n.s.

Table 4.12 Two-way ANOVA for VOT in bare stops

The results for the two-way ANOVA show a main effect for both LENIS/FORTIS and place, but no interaction. Interestingly, the effect size for place is larger than the effect size for LENIS/FORTIS. Because the differences in place of articulation are so clear, I also computed separate one-way ANOVAs for my results. A one-way ANOVA for the difference in VOT between /b/~/p/ in my results shows that the difference is statistically significant (F (1, 62) = 4.80, *p* = 0.0322) but the effect size is small (omega^2 = 0.06). The difference in VOT between /d/~/t/ is also statistically significant (F (1, 61) = 15.47, *p* = 0.0002) and with a larger effect size (omega^2 = 0.19).

VOT in stop-sonorant clusters shows some large increases:

LENIS	mean VOT in ms	s.d.	FORTIS	mean VOT in ms	s.d.
/bl-/	14.97	6.45	/pl-/	28.77	12.45
/br-/	20.94	9.70	/pr-/	36.20	17.56
/dr-/	32.77	13.79	/tr-/	53.61	16.86
/dʋ-/	49.08	23.97	/tʋ-/	96.85	23.81
			/kl-/	62.51	14.29
			/kn-/	64.75	20.18
			/kr-/	60.78	17.66
			/kʋ-/	79.42	18.83

Table 4.13 Results for mean VOT in ms in stop-sonorant clusters

Although van Alphen & Smits include stop-sonorant clusters in their study (2004:466-467), they do not report those results separately; apparently, their results for the stop-sonorant clusters were not different enough to report them separately. This is clearly not the case for the results I present here, with considerable increases in VOT for /t/ and /k/ in clusters (especially /tʋ-/ and /kʋ-/), but not as much of an increase for /p/; these results are also 10-20 ms longer than those reported for stop + sonorant clusters in Belgian Dutch by Simon (2010:80) cited above.

4.5.1.5. Sonorant duration

		bare	/b__/	/p__/	/d__/	/t__/	/k__/
l		/l-/	/bl-/	/pl-/			/kl-/
	mean	100.79	57.25	48.23			64.72
	st. dev.	22.40	24.27	13.17			11.13
m		/m-/					
	mean	111.06					
	st. dev.	18.68					
n		/n-/					/kn-/
	mean	108.25					62.12
	st. dev.	24.04					10.21
r		/r-/	/br-/	/pr-/	/dr-/	/tr-/	/kr-/
	mean	78.76	48.30	41.01	51.84	47.04	43.41
	st. dev.	31.10	26.46	20.97	29.81	23.63	21.68
w		/ʋ-/			/dʋ-/	/tʋ-/	/kʋ-/
	mean	91.56			65.18	66.62	66.78
	st. dev.	25.03			12.82	13.18	9.97

Table 4.14 Mean sonorant duration in ms

As expected based on the results for Norwegian in Chapter 3, bare sonorants have a longer sonorant duration than in obstruent+sonorant clusters.

4.5.1.6. Sonorant devoicing and % sonorant voicing

Results for stop + /l/ clusters:

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/pl-/	7.97	11.06	83.27	22.35	0	20/32
/kl-/	32.52	13.89	49.28	19.91	0	1/32

Table 4.15 Results for mean sonorant devoicing of /l/ in ms, % sonorant voicing, and the number of tokens with 0% and 100% voiced sonorants

Although there is very little sonorant devoicing in /pl-/ clusters, /kl-/ shows much more, with just over 50% of the /l/ devoiced, corresponding to the increased VOT mentioned above (ca. 60 ms).

The results for /kn-/ clusters show that some sonorant devoicing is taking place, but much less than in /kl-/ clusters:

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/kn-/	18.41	15.79	69.06	26.02	1	9/32

Table 4.16 Results for mean sonorant devoicing of /n/ in ms, % sonorant voicing, and the number of tokens with 0% and 100% voiced sonorants

The results for all stop + /r/ clusters, including tokens with schwa epenthesis, show that /r/ generally resists devoicing:

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/pr-/	11.68	16.60	76.62	33.22	1	20/32
/tr-/	9.38	15.32	83.93	26.45	0	22/32
/kr-/	13.63	16.60	75.68	30.85	0	18/32

Table 4.17 Results for mean sonorant devoicing of /r/ in ms, including tokens with schwa epenthesis, % sonorant voicing, and the number of tokens with 0% and 100% voiced sonorants

The results for stop + /r/ clusters, excluding tokens with schwa epenthesis, show higher rates of sonorant devoicing, even in /pr-/ clusters where VOT is shorter (38 ms) than in /tr-/ (55 ms) and /kr-/ (60 ms) clusters:

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/pr-/	21.98	17.13	56.00	34.26	1	5/17
/tr-/	17.66	17.31	69.75	29.99	0	7/17
/kr-/	29.08	11.34	48.13	23.99	0	1/15

Table 4.18 Results for mean sonorant devoicing of /r/ in ms, excluding tokens with schwa epenthesis, % sonorant voicing, and the number of tokens with 0% and 100% voiced sonorants

Figure 4.3 shows partial devoicing of /r/:

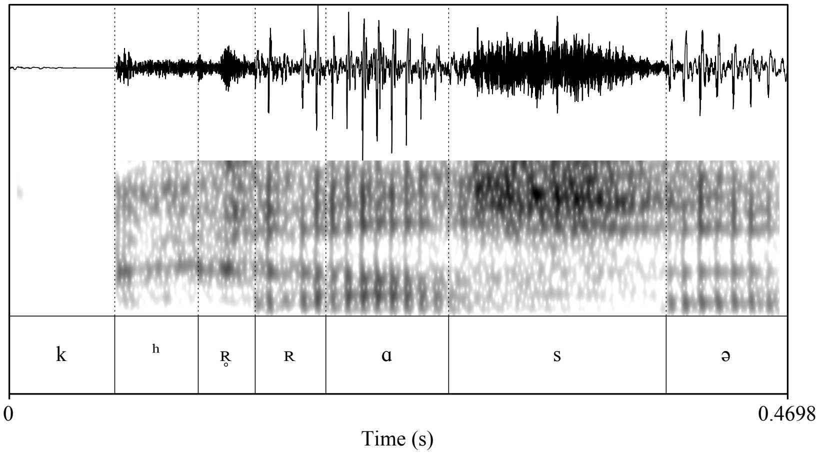

Figure 4.3 Token of *krassen* ‘to scrape’ from speaker M5

Sonorant devoicing in /tʋ-/ and /kʋ-/ clusters is by far the most extensive, with on average about 75% of the sonorant devoiced:

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/tʋ-/	52.25	15.09	20.70	20.18	10	0/31
/kʋ-/	52.24	17.60	22.83	20.05	10	0/32

Table 4.19 Results for mean sonorant devoicing of /ʋ/ in ms, % sonorant voicing, and the number of tokens with 0% and 100% voiced sonorants

Figure 4.4 illustrates a completely devoiced /tʋ-/ cluster:

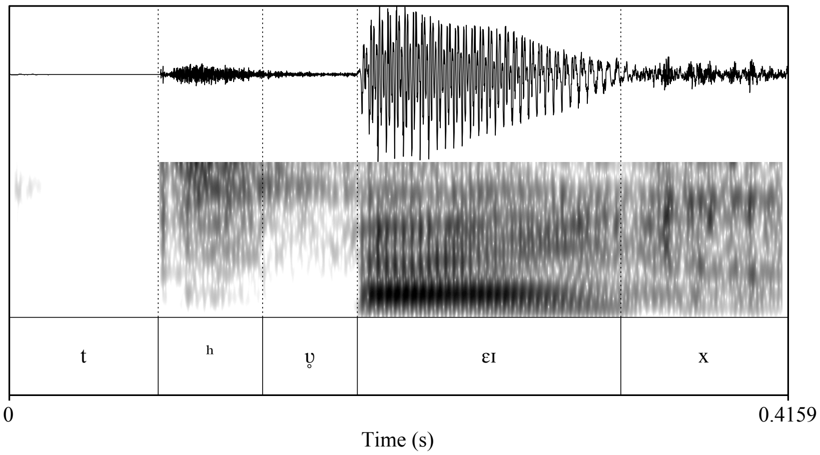

Figure 4.4 Token of *twijg* 'twig' from speaker F2

Generally speaking, most of the stop + sonorant clusters exhibit some sonorant devoicing, but the duration of devoicing shows considerable variation between cluster types; /pl-/ clusters have very little sonorant devoicing, but /tʋ-/ and /kʋ-/ clusters are mostly voiceless.

4.5.1.7. Sonorant voicing duration

LENIS	mean son. voi. in ms	s.d.	FORTIS	mean son. voi. in ms	s.d.
/bl-/	57.25	24.27	/pl-/	40.27	16.16
/br-/	47.69	26.29	/pr-/	29.33	20.51
/dr-/	47.83	31.32	/tr-/	37.66	23.13
/dʋ-/	48.88	24.11	/tʋ-/	14.37	15.23
			/kl-/	32.20	14.96
			/kn-/	43.71	19.81
			/kr-/	29.78	16.46
			/kʋ-/	14.55	12.57

Table 4.20 Results for mean sonorant voicing duration in ms

This comparison reveals that the visibly voiced portion of the sonorant is shorter following FORTIS stops, corresponding to an increase in VOT following these stops (and some sonorant devoicing) rather than a decrease in sonorant duration.

4.5.2. Fricatives

Due to the dual sonorant-fricative behavior of /ʋ/ (van der Torre 2003:181-204), it is included here as both a sonorant and a fricative.

4.5.2.1. Fricative duration

		bare	/l/	/m/	/n/	/r/	/ʋ/
<w>		/ʋ-/				/ʋr-/	
	mean	91.56				106.04	
	st. dev.	25.03				28.12	
<v>		/v-/	/vl-/			/vr-/	
	mean	124.33	122.06			116.91	
	st. dev.	18.65	18.86			20.73	
<f>		/f-/	/fl-/			/fr-/	
	mean	147.26	132.56			128.87	
	st. dev.	22.86	27.84			29.36	
<z>		/z-/					/zʋ-/
	mean	123.18					118.53
	st. dev.	26.05					30.77
<s>		/s-/	/sl-/	/sm-/	/sn-/		
	mean	161.95	144.69	156.24	163.14		
	st. dev.	22.20	29.48	24.84	26.37		
<g>		[x-]	[xl-]		[xn-]	[xr-]	
	mean	142.93	118.96		137.41	133.36	
	st. dev.	29.61	27.17		32.93	20.95	

Table 4.21 Results for mean fricative duration in ms for bare fricatives and fricative-sonorant clusters

For the bare fricatives, ANOVAs were run for the pairs /v/~/f/ and /z/~/s/, and the results show that fricative duration is highly statistically significant for both pairs, with fairly large effect sizes:

/v/~/f/	F (1, 61) = 18.97	$p = 0.0001$	omega^2 = 0.22
/z/~/s/	F (1, 62) = 41.06	$p < 0.0001$	omega^2 = 0.39

Table 4.22 ANOVAs for fricative duration; /v/~/f/ and /z/~/s/

4.5.2.2. VoffT (pulsing duration)

bare	mean VoffT in ms	s.d.
/ʋ-/	84.63	26.31
/v-/	18.64	15.33
/f-/	11.82	9.52
/z-/	50.07	41.59
/s-/	12.52	5.75
[x-]	16.76	10.32

cluster	mean VoffT in ms	s.d.
/ʋr-/	67.08	35.68
/v-/	25.96	19.24
/f-/	16.71	9.41
/zʋ-/	39.94	40.76
/s-/	11.96	6.98
[x-]	14.76	8.94

Table 4.23 Results for mean VoffT in ms in bare fricatives and fricative-sonorant clusters

Compared to bare fricatives, fricative-sonorant clusters show a large decrease in VoffT for /ʋ/ and small decreases for /z/, /s/, and [x], but /v/ and /f/ both show small increases. One-way ANOVAs were run for VoffT in the pairs /v/~/f/ and /z/~/s/; while VoffT just reaches statistical significance for /v/~/f/, it is highly significant for /z/~/s/:

/v/~/f/:	F (1, 61) = 4.53	$p = 0.0373$	omega^2 = 0.05
/z/~/s/:	F (1, 62) = 25.59	$p < 0.0001$	omega^2 = 0.28

Table 4.24 ANOVAs for fricative VoffT; /v/~/f/ and /z/~/s/

These results show that /z/ is typically voiced far more than the other fricatives (with the exception of /ʋ-/); Figure 4.5 illustrates a fully voiced /z/:

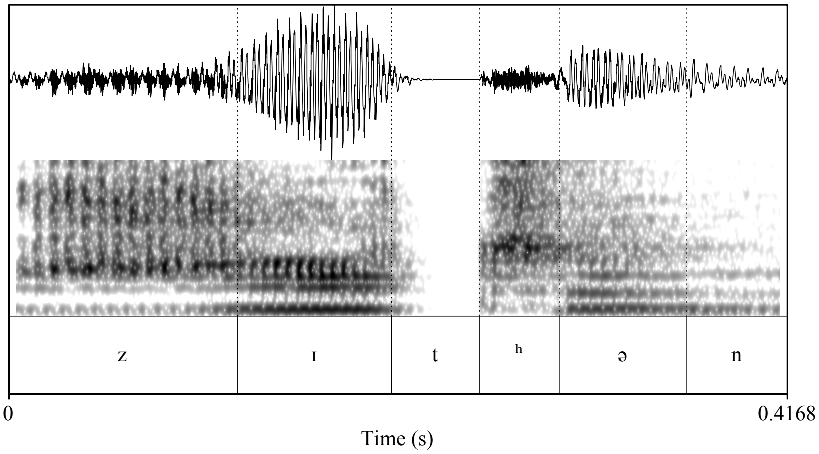

Figure 4.5 Token of *zitten* 'to sit' from speaker M3 with a fully voiced /z/ (spectrogram 0-10 kHz to better show pulsing in /z/)

4.5.2.3. % glottal pulsing

bare	mean % pulsing	s.d.	cluster	mean % pulsing	s.d.
/ʋ-/	93.67	18.93	/ʋr-/	65.35	36.66
/v-/	15.03	11.86	/v-/	22.43	17.52
/f-/	8.09	6.36	/f-/	12.84	6.61
/z-/	44.39	39.91	/zʋ-/	35.51	38.83
/s-/	7.68	3.47	/s-/	7.95	4.86
[x-]	11.98	7.47	[x-]	12.12	8.06

Table 4.25 Results for mean % glottal pulsing in bare fricatives and fricative-sonorant clusters

Fricative-sonorant clusters show similar results to VoffT above, with generally less voicing, though [x-] shows a slight increase rather than a decrease. ANOVAs were run for % glottal pulsing for /v/~/f/ and /z/~/s/. This measure is shown to be statistically significant for /v/~/f/ and highly statistically significant for /z/~/s/:

/v/~/f/:	F (1, 61) = 8.43	*p* = 0.0051	omega^2 = 0.11
/z/~/s/:	F (1, 62) = 26.88	*p* < 0.0001	omega^2 = 0.29

Table 4.26 ANOVAs for % glottal pulsing; /v/~/f/ and /z/~/s/

4.5.2.4. Sonorant duration following fricatives

		bare	/ʋ__/	/v__/	/f__/	/z__/	/s__/	[x__]
l		/l-/		/vl-/	/fl-/		/sl-/	[xl-]
	mean	100.79		47.82	49.49		49.99	57.55
	st. dev.	22.40		11.90	10.71		11.92	12.06
m		/m-/					/sm/	
	mean	111.06					57.28	
	st. dev.	18.68					12.00	
n		/n-/					/sn-/	[xn-]
	mean	108.25					50.27	62.62
	st. dev.	24.04					10.10	12.67
r		/r-/	/ʋr-/	/vr-/	/fr-/			[xr-]
	mean	78.76	47.91	44.91	40.38			39.55
	st. dev.	31.10	24.82	22.53	18.02			16.09
w		/ʋ-/				/zʋ-/		
	mean	91.56				50.66		
	st. dev.	25.03				9.64		

Table 4.27 Results for mean sonorant duration in ms

As expected, we see shorter sonorant duration in fricative-sonorant clusters than for bare word-initial sonorants.

4.5.2.5. Fricative sonorant devoicing and % sonorant voicing

As noted above, /ʋ/ is not always 100% voiced; this also resulted in two tokens (from two different speakers) of /ʋr-/ that exhibited some partial sonorant devoicing (36.23 ms and 27.76 ms). The remaining results are given below.

The results for fricative + /l/ clusters generally show minimal sonorant devoicing, similar to /pl-/ above:

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/vl-/	7.99	11.62	83.09	26.38	1	20/32
/fl-/	15.05	15.26	69.54	30.08	1	13/31
/sl-/	20.45	15.10	59.07	31.19	3	8/31
[xl-]	19.24	13.23	65.38	23.22	0	8/32

Table 4.28 Results for mean sonorant devoicing of /l/ in ms, % sonorant voicing, and the number of tokens with 0% and 100% voiced sonorants

ANOVAs were calculated for /vl-/~/fl-/ for both sonorant devoicing and % sonorant voicing, with statistically significant results for sonorant devoicing but not for % sonorant voicing:

son. dev.	F (1, 61) = 4.29	*p* = 0.0426	omega^2 = 0.05
% son. voi.	F (1, 61) = 3.62	*p* = 0.0617	omega^2 = 0.04

Table 4.29 ANOVAs for sonorant devoicing and % sonorant voicing; /vl-/~/fl-/

Additional ANOVAs were run with place of articulation as the independent variable for /fl-/, /sl-/, and [xl-], with no statistically significant results for either sonorant devoicing or % sonorant voicing:

son. dev.:	F (2, 91) = 1.18	*p* = 0. 3125	n.s.
% son. voi.:	F (2, 91) = 1.07	*p* = 0. 3459	n.s.

Table 4.30 ANOVAs for sonorant devoicing and % sonorant voicing; /fl-/, /sl-/, [xl-]

These results indicate that there is no statistically significant difference between /f/, /s/, and [x] with regard to devoicing of /l/. Figure 4.6 illustrates partial devoicing of /l/ in a [xl-] cluster:

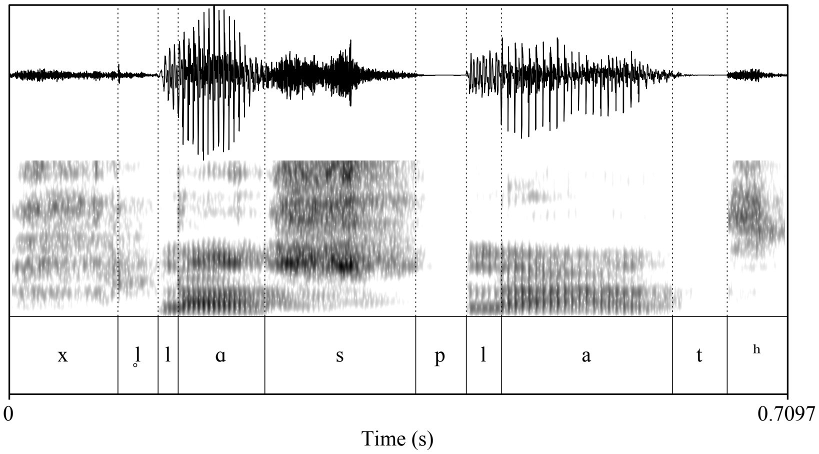

Figure 4.6 Token of *glasplaat* 'glass plate' from speaker F1 showing partial devoicing of /l/

The results for /sm-/ clusters show marginal sonorant devoicing:

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/sm-/	9.87	9.82	82.67	17.51	0	15/32

Table 4.31 Results for mean sonorant devoicing of /m/ in ms, % sonorant voicing, and the number of tokens with 0% and 100% voiced sonorants

The results for fricative + /n/ clusters also show very little sonorant devoicing:

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/sn-/	12.40	10.69	74.95	22.44	0	12/32
[xn-]	10.89	11.30	81.92	18.31	0	14/31

Table 4.32 Results for mean sonorant devoicing of /n/ in ms, % sonorant voicing, and the number of tokens with 0% and 100% voiced sonorants

ANOVAs were calculated for this pair, and the results show no statistically significant difference for either sonorant devoicing or % sonorant voicing:

son. dev.:	F (1, 61) = 0.30	*p* = 0. 5883	n.s.
% son. voi.:	F (1, 61) = 1.82	*p* = 0. 1825	n.s.

Table 4.33 ANOVAs for sonorant devoicing and % sonorant voicing; /sn-/~[xn-]

As noted in Table 4.27 above, the mean duration of /n/ is longer in [xn-] than in /sn-/ clusters; thus even though the duration of sonorant devoicing is approximately the same (Table 4.32), the duration of the sonorant is different.

The results for fricative + /r/ clusters show some sonorant devoicing in /fr-/ clusters:

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/vr-/	6.13	12.32	87.12	26.93	1	25/32
/fr-/	17.73	17.76	59.59	39.97	5	14/32
[xr-]	5.80	9.34	84.94	23.86	0	21/30

Table 4.34 Results for mean sonorant devoicing of /r/ in ms, % sonorant voicing, and the number of tokens with 0% and 100% voiced sonorants

ANOVAs were calculated for /vr-/~/fr-/ for these measures, with results showing statistically significant differences for both sonorant devoicing and % sonorant voicing:

son. dev.:	F (1, 62) = 9.21	*p* = 0. 0035	omega^2 = 0.11
% son. voi.:	F (1, 62) = 10.45	*p* = 0. 0020	omega^2 = 0.13

Table 4.35 ANOVAs for sonorant devoicing and % sonorant voicing; /vr-/~/fr-/

ANOVAs for /fr-/~[xr-] show statistically significant differences for both sonorant devoicing and % sonorant voicing, which is unsurprising given the similar results for /vr-/ and [xr-]:

son. dev.:	F (1, 60) = 10.74	*p* = 0. 0017	omega^2 = 0.14
% son. voi.:	F (1, 60) = 9.05	*p* = 0. 0038	omega^2 = 0.12

Table 4.36 ANOVAs for sonorant devoicing and % sonorant voicing; /fr-/~[xr-]

Even though /z-/ is often phonetically voiced (only /ʋ-/ is voiced more; Table 4.23 above), that voicing tends to occur at the beginning of the segment, with voicelessness at the end; here we see that the end-of-segment voicelessness is sometimes sufficient to devoice a following /ʋ/:

	mean son. dev. in ms	s.d.	mean % son. voicing	s.d.	# 0%	# 100%
/zʋ-/	19.12	20.84	61.87	40.96	4	16/32

Table 4.37 Results for mean sonorant devoicing of in /ʋ/ ms, % sonorant voicing, and the number of tokens with 0% and 100% voiced sonorants

Generally speaking, there seems to be less sonorant devoicing after fricatives than after stops, with % sonorant voicing typically between 60-80%. Statistically significant differences are often found between /f/ + sonorant and /v/ + sonorant clusters, but it is also interesting that some sonorant devoicing occurs in /v/ + sonorant clusters; as noted above, /v/ is often produced without phonetic voicing, but these results indicate that /v/ is voiceless enough to occasionally devoice a following sonorant.

4.5.2.6. Sonorant voicing duration following fricatives

LENIS	mean son. voi. in ms	s.d.	FORTIS	mean son. voi. in ms	s.d.
/vl-/	39.83	15.75	/fl-/	34.44	17.64
			/sl-/	29.54	16.77
			[xl-]	38.31	17.44
			/sm-/	47.41	15.07
			/sn-/	37.87	14.36
			[xn-]	51.73	17.11
/ʋr-/	45.84	26.36			
/vr-/	38.78	24.43	/fr-/	22.65	21.06
			[xr-]	33.75	17.49
/zʋ-/	31.54	22.35			

Table 4.38 Results for mean sonorant voicing duration in ms following fricatives

Various ANOVAs were run for this measure. The results for /vl-/~/fl-/ and /fl-/, /sl-/, and [xl-] show no statistically significant difference in the duration of sonorant voicing. The difference between /sn-/ and [xn-] for this measure is statistically significant. (Notice again in Table 4.27 above that /n/ appears to be 10 ms longer in [xn-] clusters than in /sn-/ clusters, which could have some bearing on these results.) The results for /vr-/~/fr-/ and /fr-/~[xr-] are also statistically significant:

/vl/~/fl/	F (1, 61) = 1.64	*p* = 0.2048	n.s.
/fl/, /sl/, [xl]	F (2, 91) = 2.03	*p* = 0.1367	n.s.
/sn/~[xn]	F (1, 61) = 12.16	*p* = 0.0009	omega^2 = 0.15
/vr/~/fr/	F (1, 62) = 8.00	*p* = 0.0063	omega^2 = 0.10
/fr/~[xr]	F (1, 60) = 5.06	*p* = 0.0282	omega^2 = 0.06

Table 4.39 ANOVAs for sonorant voicing duration in fricative + sonorant clusters

These results indicate that in contrast to the stops in Table 4.20 above, there is no clear pattern of sonorant voicing duration differences between LENIS and FORTIS fricatives.

4.5.2.7. Stops and fricatives compared

Sonorant devoicing, stops and fricatives compared:

stop	mean son. dev. in ms	s.d.	fric.	mean son. dev. in ms	s.d.
/pl-/	7.97	11.06	/fl-/	15.05	15.26
			/sl-/	20.45	15.10
/kl-/	32.52	13.89	[xl-]	19.24	13.23
			/sn-/	12.40	10.69
/kn-/	18.41	15.79	[xn-]	10.89	11.30
/pr-/	21.98	17.13	/fr-/	17.73	17.76
/tr-/	17.66	17.31			
/kr-/	29.08	11.34	[xr-]	5.80	9.34

Table 4.40 Comparison of sonorant devoicing for stops and fricatives

With the exception of /fl-/ there is generally less sonorant devoicing after fricatives than stops. This changes somewhat for /Cr-/ clusters if we include tokens with schwa epenthesis for stops:

stop	mean son. dev. in ms	s.d.	fric.	mean son. dev. in ms	s.d.
/pr-/	11.68	16.60	/fr-/	17.73	17.76
/tr-/	9.38	15.32			
/kr-/	13.63	16.60	[xr-]	5.80	9.34

Table 4.41 /Cr-/ clusters including schwa epenthesis

% Sonorant voicing, stops and fricatives compared:

stop	mean % son. voicing	s.d.	fric.	mean % son. voicing	s.d.
/pl-/	83.27	22.35	/fl-/	69.54	30.08
			/sl-/	59.07	31.19
/kl-/	49.28	19.91	[xl-]	65.38	23.22
			/sn-/	74.95	22.44
/kn-/	69.06	26.02	[xn-]	81.92	18.31
/pr-/	56.00	33.22	/fr-/	59.59	39.97
/tr-/	69.75	29.99			
/kr-/	48.13	23.99	[xr-]	84.94	23.86

Table 4.42 Comparison of % sonorant voicing for stops and fricatives

Again, with the exception of /fl-/ there is generally a greater percentage of voiced sonorant after fricatives than after stops. Here tokens with schwa epenthesis for stops are included for comparison:

stop	mean % son. voicing	s.d.	fric.	mean % son. voicing	s.d.
/pr-/	76.62	33.22	/fr-/	59.59	39.97
/tr-/	83.93	26.45			
/kr-/	75.68	30.85	[xr-]	84.94	23.86

Table 4.43 % sonorant voicing including schwa epenthesis

Regardless of the cause or purpose of schwa epenthesis, it clearly has an effect on the degree to which sonorant devoicing occurs.

Sonorant voicing duration, stops and fricatives compared:

stop	mean son. voi. in ms	s.d.	fric.	mean son. voi. in ms	s.d.
/pl-/	40.27	16.16	/fl-/	34.44	17.64
			/sl-/	29.54	16.77
/kl-/	32.20	14.96	[xl-]	38.31	17.44
			/sn-/	37.87	14.36
/kn-/	43.71	19.81	[xn-]	51.73	17.11
/pr-/	29.33	20.51	/fr-/	22.65	21.06
/tr-/	37.66	23.13			
/kr-/	29.78	16.46	[xr-]	33.75	17.49

Table 4.44 Comparison of sonorant voicing duration for stops and fricatives

With the exception of /fl-/ and /fr-/, obstruents with the same place of articulation show slightly more voiced sonorant after fricatives than after stops, indicating that there is generally less sonorant devoicing after FORTIS fricatives than there is after FORTIS stops.

4.5.3. Regressive voicing assimilation

4.5.3.1. Obstruent + LENIS fricative/sonorant: *bladzijde*, *bloedvat*, *noodweer*, *huiswerk*

As expected based on Zonneveld (2007) and other accounts of Dutch phonology, the medial clusters in *bladzijde* 'page' and *bloedvat* 'blood vessel' are consistently produced as voiceless (*bla*[ts]*ijde*, *bloe*[tf]*at*/*bloe*[t^{h}f]*at*). The mean VoffT for *bladzijde* is 30.66 ms and for *bloedvat* is 33.64 ms. On the other hand, *noodweer* 'self defense' is often realized as *noo*[tf]*eer* (with /ʋ/ completely devoiced), but is also realized as partially or fully voiced; of the 15 tokens analyzed, 11 are mostly or completely voiced while 4 are mostly or completely devoiced (mean VoffT for /d/: 32.31 ms; mean % voicing of /ʋ/: 33.70%). Finally, *huiswerk* 'homework' shows a greater tendency for voicing, but usually only on /ʋ/; /s/ shows some voicing at the onset of frication rather than in the portion adjacent to /ʋ/ (mean VoffT for /s/: 20.58 ms; cf. 12.52 ms for word-initial /s/ in Table 4.23 above) but /ʋ/ is mostly voiced (mean % voicing of /ʋ/: 63.19%). Therefore, while /v/ and /z/ are consistently produced as voiceless, /ʋ/ is often realized as partially or fully voiced, though this did not appear to have an effect on the VoffT of a preceding /d/.

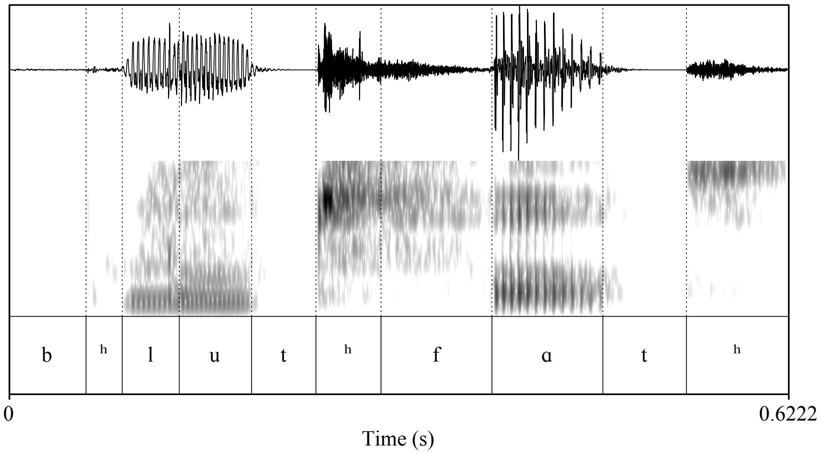

Figure 4.7 Token of *bloedvat* 'blood vessel' from speaker F1

4.5.3.2. Fricative + LENIS stop *dagblad*, *huisdier*, *ijsbeer*, *leefbaar*

Interestingly, all tokens of *dagblad* 'newspaper' show completely voiceless [xb̥] clusters (mean VoffT for [x]: 8.67 ms) for all speakers (16 tokens). There are several tokens of *huisdier* 'pet' that show some voicing of /s/ (up to 40%; mean: 31.68%; mean VoffT: 28.29 ms) and two tokens that are voiced throughout the cluster (*hui*[zd]*ier*); /d/ is otherwise voiceless, and approximately half of the tokens show no sign of voicing (16 tokens total). For *ijsbeer* 'polar bear', there is again some voicing of /s/ (mean: 22.98%; mean VoffT: 22.43 ms), one token with both segments completely voiced, and four tokens with a prevoiced /b/; otherwise, /b/ shows no voicing. Finally, *leefbaar* 'livable' has approximately the same pattern as *huisdier* and *ijsbeer*, with a full range of zero to fully voiced /f/ (mean: 38.98%; mean VoffT: 31.57 ms), two fully voiced tokens (*lee*[vb]*aar*), and one case of mostly voiceless /f/ followed by prevoiced /b/.

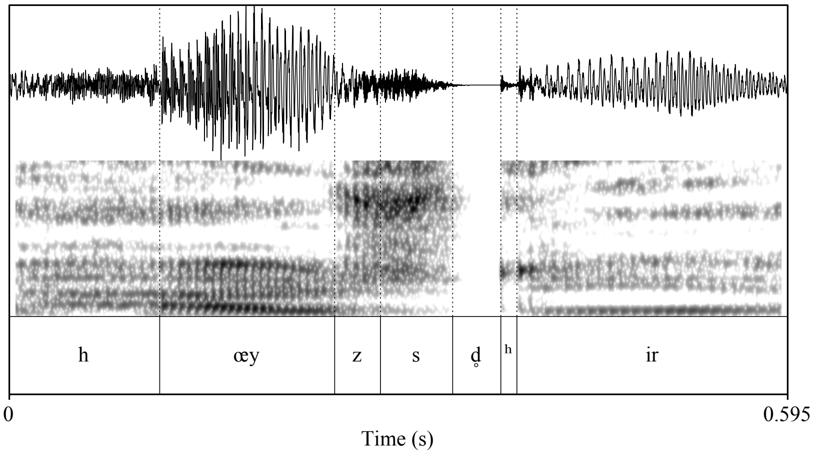

Figure 4.8 Token of *huisdier* 'pet' from speaker M3

4.5.3.3. Stop + stop clusters *braadpan*, *breedband*, *laadbak*, *zakdoek*

As expected, the /dp/ cluster in *braadpan* ‘casserole’ is voiceless (aside from the expected voicing tail going into the closure of /d/). However, what was unexpected is that the medial /db/ cluster in *breedband* ‘broadband’ is in most cases identical to /dp/ in *braadpan*. In fact, of the 16 tokens of *breedband* that were analyzed, only one shows clear voicing in both segments (Figure 4.12 below). Additionally, in approximately half of the tokens of both words, the first segment is unreleased; in the other half where there is release, there is a mean duration of approximately 42 ms of aspiration for both *braadpan* and *breedband*. However, if we examine the combined closure duration of both segments minus the release (or the total closure duration if the first stop is unreleased), the closure duration of the /dp/ cluster in *braadpan* is 113 ms while the closure duration of the /db/ cluster in *breedband* is 98 ms. In the case of *laadbak* ‘loading platform’, there are two cases of prevoiced /b/, but it is otherwise similar to *breedband*, including the distribution of unreleased stops (slightly less than half were unreleased), the duration of aspiration when the stop is released (44 ms), and the total closure duration (98 ms). Furthermore, there are a few tokens of each word where the /d/ appears to have an incomplete closure and is realized as more of a weak voiceless fricative (or possibly affricate) than a stop (Figures 4.9 and 4.10 below). Finally, there are no cases of the oft-cited *zakdoek* ‘handkerchief’ that show more than a short voicing tail on /k/ or any voicing of /d/ (Figure 4.13). Mean VoffT for all four words is ca. 20-25 ms.

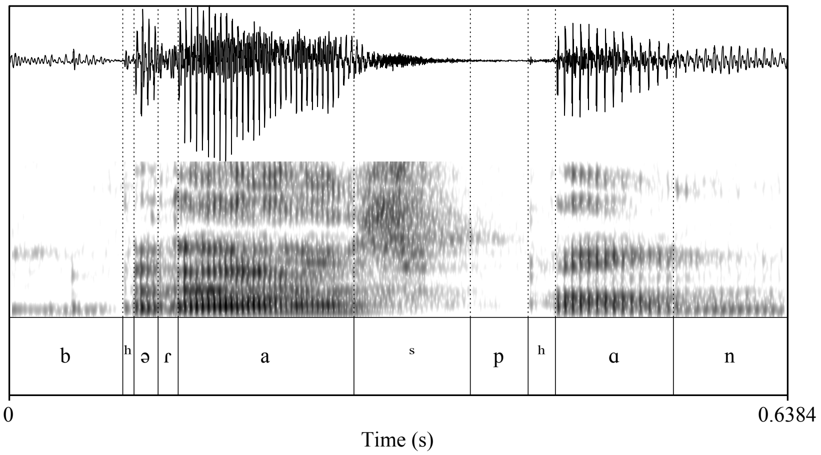

Figure 4.9 Token of *braadpan* 'casserole' from speaker F1; notice that the /d/ is realized as a voiceless fricative

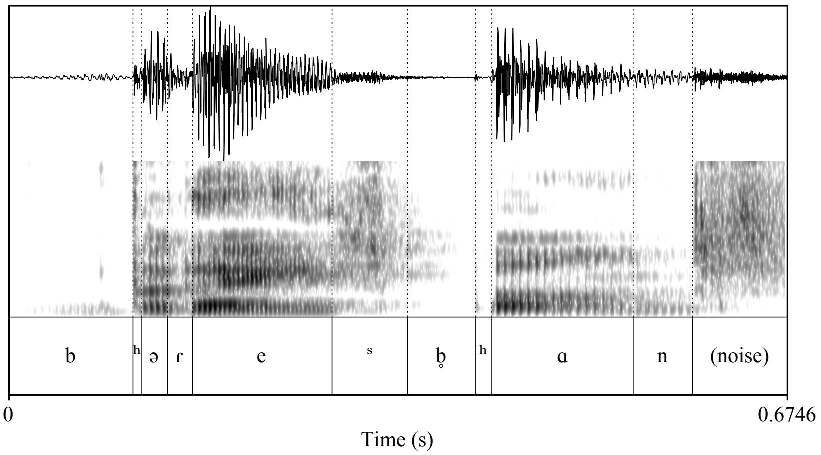

Figure 4.10 Token of *breedband* 'broadband' also from speaker F1; the initial /b/ clearly shows some prevoicing, but the medial /b/ does not (the /d/ is also realized as a voiceless fricative, perhaps an incomplete alveolar closure)

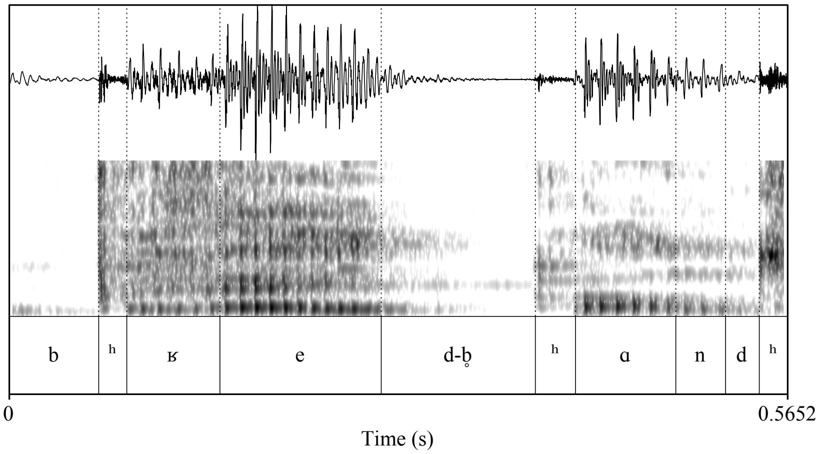

Figure 4.11 Token of *breedband* 'broadband' from speaker M1; this is somewhat typical of what I found in my data, though with less medial glottal pulsing and usually no prevoicing of the initial stop

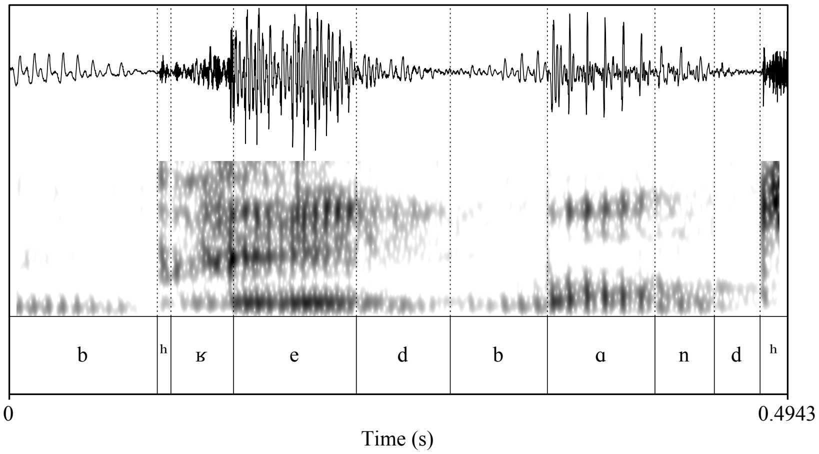

Figure 4.12 Token of *breedband* 'broadband' from speaker M4; this is the only token of its kind in my data, with voicing throughout both stop closures (as well as clear prevoicing of the initial /b/)

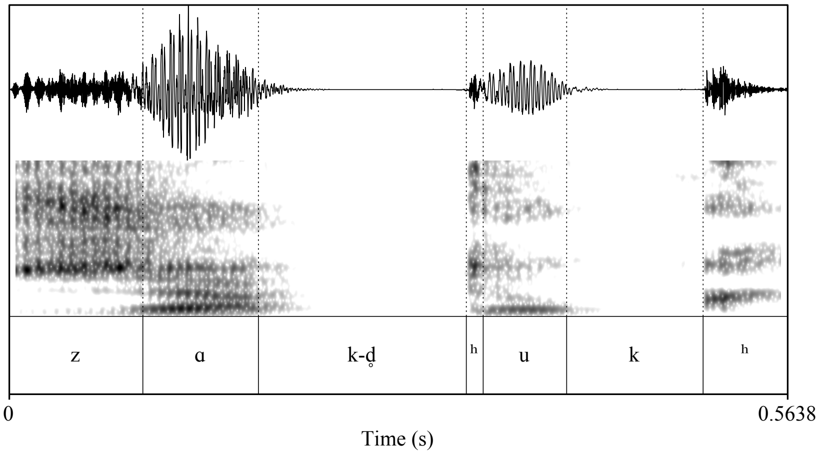

Figure 4.13 Token of *zakdoek* 'handkerchief' from speaker M3; this is typical of what I found in my data, though usually with a voiceless initial /z/ and sometimes with a released /k/

Although Grijzenhout (2001) mentions Randstad Dutch as lacking RVA, she gives the phonetic transcription of *zakdoek* 'handkerchief' as za[k.d]oek, which implies /d/ is still phonetically voiced. In the data provided here, however, the second segment in the clusters is nearly always phonetically voiceless. My results here are more in line with those of van Dommelen (1983) where very little phonetic voicing is present in the C2 of these clusters.

4.6. Analysis and conclusion

Based on the findings of previous instrumental studies of Dutch obstruents, I set up the experiments for this chapter expecting to find several things:

1) phonetic voicing in /b, d/ (Lisker & Abramson 1964, van Alphen & Smits 2004)
2) little or no phonetic voicing in /v, z, ɣ/ (Gussenhoven & Bremer 1983; Slis & van Heugten 1989; Kissine et al. 2003, 2005; Pinget 2015)
3) short-lag VOT for /p, t, k/ (Lisker & Abramson 1964, van Alphen & Smits 2004)
4) no sonorant devoicing after /p, t, k/ (van Alphen & Smits 2004)

5) OR: possibly some sonorant devoicing (Simon 2010)
6) durational differences between LENIS and FORTIS obstruents (Slis 1970; Slis & van Heugten 1989; Kissine et al. 2003, 2005; Pinget 2015)
7) RVA: a fair amount of phonetic voicing in /b, d/ as the second segment in word-internal clusters in compound words (Slis 1986) or possibly very little phonetic voicing (van Dommelen 1983)

Although many of the tokens in this study with word-initial LENIS stops exhibit phonetic voicing, there are also statistically significant durational differences between LENIS and FORTIS obstruents, with LENIS obstruents being shorter. This finding matches that of previous studies such as Slis & Cohen (1969), Slis (1970), Slis & van Heugten (1989), and Pinget (2015). However, compared to Pinget's (2015:46) results, the results presented here have both a slightly longer duration (108.97 ms compared to Pinget's 102 ms for /b/) and slightly lower percent glottal pulsing (64.18% compared to Pinget's 75.8% for /b/). My results also show a general lack of voicing in LENIS fricatives, especially /ɣ/, which I transcribe as [x] throughout. This is also unsurprising since that is what has been reported for Dutch LENIS fricatives in the literature (Booij 1995, Gussenhoven & Bremer 1983, Van de Velde et al. 1996, etc.). However, there is still at least some (or in many cases, quite a bit of) phonetic voicing present in /v, z/, and the duration of voicing as well as fricative duration were found to be statistically significant compared to /f, s/, so it would be incorrect to say that the voicing distinction for these fricatives has been neutralized for the Randstad Dutch speakers in this experiment. It is possible that the /ɣ/~/x/ contrast has been neutralized, but since /x/ only appears word-initially in loanwords, that contrast was not examined in this study; I would argue, however, that because /ɣ/ is consistently realized as [x] and exhibits as much sonorant devoicing as /f, s/, it could be categorized as a FORTIS fricative.

The two main differences between the results of this study and those of previous studies are 1) a substantial increase in VOT as well as sonorant devoicing in obstruent-sonorant clusters, and 2) a general lack of phonetic voicing in word-internal obstruent-obstruent clusters in compound words. The first point has some support from Simon (2010) who notices an increase in VOT in Belgian Dutch stop + sonorant clusters, and the second point is at least partially supported by Grijzenhout (2001) who reports that LENIS stops do not trigger RVA in Randstad Dutch, which is the variety of Dutch spoken by the subjects in this study. However, as mentioned previously, her transcriptions such as za[k.d]oek imply that the second segment is still phonetically voiced, which is almost never the case in the results here. In my results, there is very little phonetic voicing, but there is a durational difference between the medial clusters in *breedband* and *braadpan*, with the former being shorter than the latter. These results are more in line with those of van Dommelen (1983); although RVA may still be taking place, the results show that phonetic voicing is generally not being used as a strategy.

Additionally, in my results, word-initial bare /p, t, k/ are voiceless and show a short-lag VOT that is slightly longer than that reported by Lisker & Abramson (1964) but fairly close to the VOT reported by van Alphen & Smits (2004), with an increase in VOT from labial, to alveolar, to velar places of articulation. However, as noted previously, van Alphen & Smits include stop-sonorant clusters in their study, but there is apparently no difference in VOT for the clusters, so the VOT results are all pooled. In the present study, there is clearly a difference in VOT between bare stops and stop-sonorant clusters, and one consequence of the increased VOT is sonorant devoicing. It is important to note the phonetic variability, however, namely that there is only a slight increase in VOT in /p-/ clusters, with more in /t-/ and /k-/ clusters, but with a relatively wide range depending on which sonorant appears in the cluster; /tʋ-/ and /kʋ-/ clusters exhibiting by far the longest VOT and the most sonorant devoicing. Additionally, recall that there are a number of tokens that have shorter VOTs and do not exhibit sonorant devoicing. As noted in Chapters 1 and 2, this type of variation is more typical of a phonetic effect rather than a phonological process, so the results here support a phonetic interpretation, i.e. the glottal spreading gesture is phonetic rather than phonological.

An additional question I am examining in this chapter is whether the laryngeal contrast for stops is any different from the laryngeal contrast for fricatives. While one of the criteria mentioned by Iverson & Salmons (1995) for an ‘aspirating’ language is sonorant devoicing, I have shown that there is some sonorant devoicing in Dutch, which is nevertheless widely considered to be a ‘voicing’ language. In Section 4.5.2.7 above, I compare sonorant devoicing in stops and fricatives and the results show little difference between them; in fact, there appears to generally be less sonorant devoicing after FORTIS fricatives. If I am arguing that sonorant devoicing after FORTIS stops is phonetic, it would be difficult to argue that sonorant devoicing after FORTIS fricatives is phonological unless there were a clear difference between the two and more consistent sonorant devoicing after FORTIS fricatives. Additionally, there is considerably more sonorant devoicing in Norwegian fricative + sonorant clusters, as shown in Section 3.5.2.5, which I use as evidence to posit a [spr gl] specification for Norwegian FORTIS fricatives. This means that the contrastive hierarchy proposed in (6) above remains unsupported by any evidence of phonological activity for an underlying [spr gl] specification for Dutch FORTIS fricatives, and an alternative analysis is needed.

As we have seen, the phonetic implementation of [voice] does not always entail vocal fold vibration and includes additional cues to the laryngeal contrast (Slis 1970); these additional cues allowed the subjects in Slis's (1986) assimilation experiment to perceive RVA even in tokens where no phonetic voicing was present. However, a lack of phonetic voicing also caused the subjects in van Alphen & Smits's (2004) study to perceive some underlyingly [voice] tokens as underlyingly voiceless. It is therefore possible that because vocal fold vibration is frequently absent in [voice] segments, speakers may choose to enhance the contrast by increasing the phonetic gesture of the opposite, unspecified series.

In Hall's (2011) model of contrast and enhancement, the type of enhancement available is based on which features are contrastive and which are redundant, with redundant features being available for the enhancement of contrastive ones. As argued by numerous authors (e.g. Lombardi 1991, Iverson & Salmons 1995), the contrastive feature for Dutch obstruents is [voice], and [spr gl] is therefore a potential enhancing gesture. As shown by both Slis (1970) and Löfqvist et al. (1989), FORTIS obstruents in Dutch are produced with active glottal spreading and/or devoicing gestures. The presence of this type of gesture is not necessarily predicted in a narrow interpretation of laryngeal realism, but in the contrast and enhancement model, this type of gesture is expected. I argue therefore that the increased VOT and presence of sonorant devoicing in my data are the result of phonetic enhancement with [spr gl], and that the variability observed is due to additional phonetic factors. The option we are left with, then, is that [voice] is contrastive and [spr gl] is present in the FORTIS obstruents as a phonetic enhancement.

While this analysis does not directly address the RVA asymmetry, where LENIS stops induce RVA but LENIS fricatives do not, it also does not necessarily preclude the fricative devoicing or post-lexical progressive assimilation rules that are used in many analyses of Dutch RVA. However, since phonetic voicing is so often absent in Dutch LENIS fricatives, it is perhaps not surprising that LENIS fricatives do not trigger RVA. Consider also Figure 4.7 illustrating *bloedvat* by speaker F1 (reproduced here as Figure 4.14), where aspiration is clearly visible following the medial /d/:

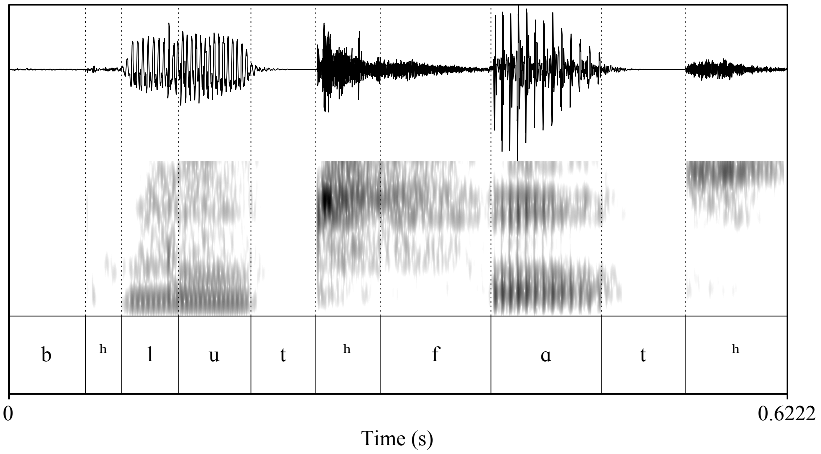

Figure 4.14 Token of *bloedvat* 'blood vessel' by speaker F1

It seems, therefore, that Final Devoicing may introduce phonetic [spr gl] rather than just remove [voice]. If this is the case, we may wonder whether the RVA asymmetry is due to a combination of factors, including the lack of phonetic voicing in LENIS fricatives, the presence of phonetic [spr gl] at prosodic right edges, and the aerodynamic requirements of fricatives in general which require a slightly spread glottis to produce a turbulent airflow.

In conclusion, the data provided in this chapter are generally in line with what has been reported elsewhere, at least in the phonetic literature, but with some important differences in VOT and sonorant devoicing in obstruent-sonorant clusters. The problem is that the phonetic literature on Dutch, the present study included, often portrays a somewhat muddy picture, making a clean phonological analysis problematic; both voicing and aspiration show considerable variation. Van Alphen & Smits (2004:487) note that "given the importance of prevoicing, why do speakers not produce prevoicing more reliably? A possible explanation is that Dutch is undergoing sound change"; this is the view taken by Pinget (2015). We could be witnessing change in progress, with an increase phonetic [spr gl] activity that has spread from the fricatives to the stops, but it is too early to tell, and the sample size in this study is too small to make that claim. If there is change in progress in Dutch, an increase in phonetic enhancement of FORTIS obstruents with [spr gl] could lead to a reanalysis of this feature as contrastive if phonetic voicing continues to decrease.

In terms of a contrastive hierarchy, we could still posit a privative [voice] analysis for Dutch, with [voice] ordered above [continuant] (where [spr gl] is ordered in Norwegian in the previous chapter) due to the presence of glottal pulsing in both LENIS stops and (to a much lesser extent) fricatives, in addition to the observed durational differences. The FORTIS obstruents would therefore be laryngeally unspecified, but phonetically enhanced with [spr gl] via Vaux's Law. However, the results of this and other experiments show considerable phonetic variation.

Although there is sonorant devoicing for both stops and fricatives in the results here, there is also wide variation generally as well as between places of articulation, which suggests a phonetic rather than phonological implementation. Additionally, the results for RVA show very little phonetic voicing and we must rely on other cues. We are therefore left without a reliable diagnostic for the phonological activity of either [voice] or [spr gl], and it would be difficult to order either feature in a contrastive hierarchy based on the available evidence.

Van Rooy & Wissing (2001) argue that the variation between dialects, between genders, between speakers, and even between different tokens from the same speaker is due to both [voice] and [tense] ([spr gl]) being used in alternation (in their view, [tense] is tied more closely to duration than aspiration). When RVA occurs, [voice] is present; when progressive devoicing occurs, [spr gl] is present. This can be seen as an indication that speakers are not consistently creating the conditions necessary for voicing on the one hand or aspiration on the other. Van Rooy & Wissing further note that RVA also occurs in Afrikaans with similar variation to Dutch, but in their study of 3-4 year old Afrikaans-speaking children, there is little prevoicing and no RVA (2001:318); thus they may be observing change in progress in Afrikaans. They state that "Afrikaans and Dutch represent an intermediate category between the more typical [tense] languages…and the more typical [voice] languages, represented by Slavic languages like Russian and Polish" (2001:319). Contrasted with Burton & Robblee's (1997) study of Russian RVA, where phonetic voicing regularly occurs and both LENIS stops and LENIS fricatives induce RVA, the situation in Dutch seems rather unstable. Based on the evidence presented in this chapter, it seems clear that both [voice] and [spr gl] are present at least at the phonetic level; but voicing of LENIS obstruents and sonorant devoicing after FORTIS obstruents are optional, and both progressive devoicing and regressive voicing take place, so it remains to be determined which of those features is phonologically active.

Chapter 5: Swiss German

5.1. Overview

Switzerland is well known for having four official languages: German, French, Italian, and Romansh;[61] however, in the case of German, there is both Swiss Standard German (or *Schriftdeutsch*) and Swiss German (or *Schwyzerdütsch*), the latter being a cover term for a number of Alemannic dialects spoken in Switzerland (Ris 1979:50). Alemannic is divided into three main groups: Low, High, and Highest Alemannic. Low Alemannic dialects[62] are spoken north of a line roughly corresponding with the northern Swiss border and Lake Constance (including adjacent areas of Baden in Germany and the Alsace in France); High Alemannic dialects comprise the majority of German-speaking Switzerland, southern parts of the Black Forest in Germany, and parts of Vorarlberg in western Austria; and Highest Alemannic dialects are spoken in the high alpine regions of southern Switzerland, northern Italy, and also in parts of Vorarlberg. The dialects discussed below belong to High Alemannic and are spoken in Switzerland, and High and Highest Alemannic are often considered synonymous with Swiss German. (Bohnenberger 1953; see also Leemann 2012:69-73 and references therein.)

In Switzerland, Standard German is learned as a second language and is limited essentially to writing, but Swiss German dialects are increasingly used in writing, enjoy high prestige, and are used in virtually all domains, including both informal and formal domains (Fagan 2009:220; see

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[61] Romansh, spoken by about 60,000 people in the canton of Graubünden (a.k.a. Grison), is further divided into five so-called *idioms*, which are not necessarily mutually intelligible: Sursilvan, Sutsilvan, Surmiran, Puter, and Vallader; see e.g. Gross (2004).

[62] Low Alemannic is sometimes separated from Swabian dialects; see e.g. König (2015:230).

also Grin 1998).[63] Willi (1996:57) quotes Schwarzenbach (1969), who speaks of the “Mundart als Symbol der demokratischen Gesellschaftsordnung” [“dialect as a symbol of the democratic social order”], as well as Sieber & Sitta (1984), who refer to the equality of dialects as “die schöne Ideologie von den sprachlich demokratischen Verhältnissen in der Schweiz” [“the beautiful ideology of the linguistically democratic conditions in Switzerland”] (see also Baur 1983). This dialect equality is perhaps part of the reason why there is no official written or spoken standard for Swiss German (the rest is likely the difficulty in accommodating the tremendous variety of dialects), and there is also no standardized orthography for any of the dialects, though some have offered suggestions (e.g. Dieth’s 1938 *Schwyzertütschi Dialäktschrift* and Marti’s 1972 *Bärndütschi Schrybwys* for Bernese). For the most part, dialect orthography seems to be based on the orthography of *Schriftdeutsch*; however, as we will see, quantity is related to the LENIS/FORTIS distinction, but quantity is not always reflected in the orthography.

An interesting feature of High and Highest Alemannic, one shared with Bavarian in Germanic (see e.g. Bannert 1977, Page 2001, Seiler 2005a) but otherwise typologically rare (Maddieson 1984:27-28), is that all stop obstruents are voiceless and unaspirated, and that the LENIS/FORTIS distinction is based instead on duration. This was noticed by early researchers (Winteler 1876, Stucki 1921, and others) and seems to be common to all High and Highest Alemannic dialects, but not to Low Alemannic (Ham 1998:85). Page (2001:233) argues that “the fortis-lenis distinction in Upper German [i.e. Alemannic and Bavarian] dialects is better understood as a contrast in phonological length”, which is the position I take in this chapter. This relates to observations made by Ohala (1983) and others that ‘voiced’/LENIS stops tend to be

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[63] See especially Rash (1998) and Christen (1998) for more on the sociolinguistic situation in German-speaking Switzerland.

shorter than their ‘voiceless’/FORTIS counterparts. Page notes furthermore (2001:249, citing Kingston & Diehl 1994 and Riad 1995) that “vowel duration serves as a [phonetic] cue for the length of a following consonant” and that “consonant duration serves as a [phonetic] cue for the length of a preceding vowel”; in most NGmc languages and Bavarian, “this phonetic tendency has been phonologized into what Riad (1995) terms Quantitative Complementarity…where a short vowel is always followed by a long consonant and a long vowel is always followed by a short consonant.” Riad (1995) argues that in most NGmc languages (Danish being the exception), consonant length is contrastive, but there is also a LENIS/FORTIS distinction based on [spr gl] (as I argue in Chapters 1 and 3); thus short consonants (whether LENIS or FORTIS) are preceded by long vowels, and long consonants (whether LENIS or FORTIS) are preceded by short vowels.[64, 65] In Bavarian, where the LENIS/FORTIS contrast is based on phonological length, LENIS (short) consonants are preceded by long vowels and FORTIS (long) consonants are preceded by short vowels; this is the so-called Bavarian Quantity Law (Bannert 1977, Seiler 2005a, Drake 2013).

In most dialects of (Swiss) Alemannic, however, vowel length is contrastive (Moulton 1986, Kraehenmann 2003, Schmid 2004, Seiler 2005b, Fleischer & Schmid 2006) in addition to the LENIS/FORTIS contrast based on phonological length; thus long and short vowels can occur before both LENIS and FORTIS obstruents. Furthermore, Ham mentions that in much of the

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[64] See Árnason (1980) for more on quantity in NGmc.

[65] In Allen (2010), I examine the speech of a single Trøndelag Norwegian speaker and find that vowels are shortest (58 ms) before FORTIS geminates (267 ms), longer (93 ms) before LENIS geminates (210 ms), still longer (167 ms) before FORTIS singletons (202 ms), and longest (254 ms) before LENIS singletons (99 ms); notice that LENIS geminates and FORTIS singletons are approximately the same duration (ca. 200 ms), but vowel duration differs by more than 70 ms before these segments. Vowel length thus appears to serve as a cue to both the durational and laryngeal contrasts in Norwegian obstruents.

descriptive literature on Swiss German, “[l]enis stops are shorter than fortis stops, which themselves are longer following short vowels than following long vowels” (1998:55), so there appears to be at least a phonetic length difference for FORTIS obstruents that is conditioned by the length of the preceding vowel.

Additionally, Seiler (2005b) cites two phonological processes that target LENIS obstruents in Bernese Swiss German (and other Swiss German dialects): monosyllabic lengthening (MSL), where underlying short vowels are lengthened in monosyllabic words before LENIS obstruents to meet a bimoraic minimal word requirement (/CVD/ → [CV:D]); and open syllable shortening (OSS), where underlying long vowels are (optionally) shortened in disyllabic words before LENIS obstruents (/CV:DV/ → [CVDV]; note that there is no requirement for stressed syllables to be heavy in Bernese. Crucially, although monosyllabic words with a long vowel followed by a FORTIS obstruent occur (/CV:T/), MSL does not affect monosyllabic words with a short vowel followed by a FORTIS obstruent (/CVT/ → [CVT], *[CV:T]); similarly, disyllabic words with a short vowel and FORTIS obstruent occur (/CVTV/), but OSS does not affect disyllabic words with a long vowel and FORTIS obstruent (/CV:TV/ → [CV:TV], *[CVTV]). Page (2001), Kraehenmann (2003), and Seiler (2005a, b) all argue based on this and other prosodic evidence (which Kraehenmann explores in some detail) that phonologically long FORTIS obstruents are weight-bearing in Upper German dialects while LENIS obstruents are non-moraic. (Ham 1998:268-295 makes a similar argument, but also separates FORTIS obstruents into a singleton/geminate contrast, with only FORTIS geminates being weight-bearing.) Because of this, the vowel length contrast interacts with the LENIS/FORTIS contrast (which is also a length contrast) in interesting ways.

This chapter presents data from a dialect of Bernese Swiss German, spoken just outside the city of Bern. Similar to the previous chapters on Norwegian and Dutch, the focus here is on word-initial obstruents and obstruent sonorant clusters, though some observations will also be made on word-medial vowel and obstruent duration. I argue that this dialect of Bernese, as with most dialects of Swiss German, lacks a contrastive laryngeal specification for the entire obstruent inventory, and that length is contrastive for both vowels and consonants, serving as the basis for the LENIS/FORTIS contrast for the obstruents. Following Seiler (2005b), who argues that length is specified for long vowels only while short vowels are underspecified for length, I propose that length is also privative for the obstruents, with LENIS obstruents unspecified for length. I begin by providing some diachronic background for the obstruent system in the modern Swiss German dialects in Section 5.2, followed by a discussion of modern Swiss German phonetics and phonology in Section 5.3. Sections 5.4 and 5.5 present the experimental data and results, and I give my analysis and conclusion in Section 5.6.

5.2. Diachronic background

In this section, I discuss a few of the sound changes that are relevant to the history of Swiss German. The main changes are WGmc gemination and the High German Consonant Shift, both of which are well known and widely studied processes, so I will only cover the basics and then discuss a few peculiarities relevant to Swiss German in more detail.

5.2.1. WGmc Gemination

WGmc gemination was mentioned in Section 1.2.6; I repeat the basics here. WGmc gemination affected all syllable-final consonants when immediately followed by *j, *l, *r, or *w. WGmc gemination was most widespread before *j, more restricted before *l and *r, and only *k was geminated before *w (e.g. Prokosch 1939:87-88; Braune 2004:98-100; Paul 2007:127-129):

1) PGmc **bidjan** > OS *biddian* ‘to ask for’ (before *j)

PGmc **apla-* > OE *æppel* ‘apple’ (before *l)

PGmc **bitraz* > OS, OHG *bittar* ‘bitter’ (before *r)

PGmc **nakwadaz* > OHG *nackot* ‘naked’ (before *w)

WGmc gemination had important consequences for the High German Consonant Shift. Moulton (1969:249-250) provides the following outline of the pre-OHG (specifically, Upper German, with WGmc *ƀ, *ð, *g̱ > /b, d, g/) obstruent inventory, after WGmc gemination had taken place, according to word position:[66]

labial					coronal					dorsal				
init.	medial		final		init.	medial		final		init.	medial		final	
p-	-p-	-pp-	-p	-pp	t-	-t-	-tt-	-t	-tt	k-	-k-	-kk-	-k	-kk
b-	-b-	-bb-	-b		d-	-d-	-dd-	-d		g-	-g-	-gg-	-g	
f-	-f-	-ff-	-f		þ-	-þ-	-þþ-	-þ		h-	-h-	-hh-	-h	
					s-	-s-	-ss-	-s						

Table 5.1 Pre-Old Upper German obstruent inventory, based on Moulton (1969:249-250)

Moulton (1969:248-249) mentions that prior to WGmc gemination, geminates were restricted to intervocalic position and were nearly always preceded by a short vowel, but WGmc gemination applied whether the preceding vowel was long or short, resulting in a large number of geminates preceded by long vowels. Braune (2004:83, 100-101) also notes that both long and short vowels

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[66] Moulton also includes sonorants; the nasals and liquids have the same distribution as the lenis stops and fricatives, and the glides lack geminates.

occur before geminates in Old Upper German, but that geminates tend to be degeminated after long vowels in later stages. In terms of laryngeal contrast, Braune (2004:82-83) argues that the lenis stops in pre-Old Upper German were already voiceless at that stage, and that the primary opposition between obstruents in Upper German was not voicing, but continuancy, i.e. between stops and fricatives. The High German Consonant Shift then operates on these segments.

5.2.2. High German Consonant Shift

By accepted definition, the German-speaking area is divided into Low German and High German, with a line running approximately east-northeast from around Aachen in the west to around Frankfurt-an-der-Oder in the east – the so-called "Benrath Line". High German is further divided into Middle (or Central) and Upper German, the latter consisting of Alemannic and Bavarian dialects. While the terms "Low German" and "High German" refer to geography (there is a rise in elevation from north to south toward the Alps), the division itself is based on a linguistic criterion: the presence or absence of any effects of the High German Consonant Shift. Specifically, the shift is absent in Low German, is present to varying degrees in Middle German, and reaches its fullest extent in Upper German.

The basics of the consonant shift are as follows, with Old Saxon (OS) representing Low German, where the shift did not take place (Braune 2004:84-89; Braune's transcriptions and examples):

2) a. WGmc singleton (aspirated) fortis stops become fortis (often geminate) fricatives after vowels (Braune 2004:84-85):

WGmc *p, *t, *k > OHG *ff*, ʒʒ, hh (ʒʒ ≠ ss; see Braune 2004:167)

OS *opan*, OHG *offan* 'open'

OS *etan*, OHG *ëʒʒan* ‘to eat’

OS *makōn*, OHG *mahhōn* ‘to make’

This shift affected all High German dialects. These become degeminated in word-final and pre-consonantal position, and eventually after long vowels: OS *skip*, OHG *skif* ‘ship’; OS *slāpan*, OHG *slāffan* > *slāfan* ‘to sleep’.

b. WGmc (aspirated) fortis stops become affricates initially, after sonorants, and as geminates (Braune 2004:85-87):

WGmc *p(p), *t(t), *k(k) > OHG [p͜f], [t͜s], [k͜χ]

OS *penning*, Upper German and East Franconian *pfenning* ‘penny’

OS *herta*, OHG *hërza* ‘heart’

OS *wekkian*, Upper German *wecchen* ‘to wake (s.o.)’

Of these changes, only *k > [k͜χ] is restricted to Upper German. Similar to Grimm’s Law, this shift did not affect fricative-stop clusters (e.g. OHG *spinnan* ‘to spin’, *naht* ‘night’, *fisk* ‘fish’), but it also did not take place in /tr/ clusters (e.g. OHG *tretan* ‘to tread’).

c. WGmc lenis stops become fortis stops (Braune 2004:87-89):

WGmc *b(b), *d(d), *g(g) > Old Upper German p(p), t(t), k(k)

OS *bëran*, Upper German *peran* ‘to bear’

OS *dohter*, Upper German and East Franconian *tohter* ‘daughter’

OS *ruggi*, Upper German *rucki* ‘back’

The *d > /t/ shift is the most widespread, but *b > /p/ and *g > /k/ are limited to Upper German, and according to Braune (2004:88), the shift is more complete in Bavarian than Alemannic.

By the end of this shift, stops, fricatives, and affricates occurred in all word positions. The shift of WGmc *p, *t, *k to either affricates or fricatives (2a, b) is traditionally referred to as the *Tenuesverschiebung* ('fortis shift') while the shift of WGmc *b(b), *d(d), *g(g) to *p(p), t(t)*, *k(k)* (2c) is the *Medienverschiebung* ('lenis shift'); it is particularly the implications of the *Medienverschiebung* that I will focus on.

5.2.3. The *Medienverschiebung*

While the core elements of the High German Consonant Shift are outlined above, recall also that the spirant allophones *ƀ, *ð, *ǥ of PGmc lenis stops had varying outcomes in WGmc; specifically, *ð became /d/ in all positions throughout WGmc, and *ƀ became /b/ and *ǥ became /g/ in all positions only in Rhine- and East Franconian as well as in Upper German (Braune 2004:89, 128-130, 141-145, 159-162). This shift must have occurred at some point before the High German Consonant Shift; however, the extent to which the lenis spirants had shifted to lenis stops does not necessarily mean those lenis stops became fortis stops in the *Medienverschiebung*. In fact, the shift from *d > *t* has the broadest distribution but is still limited to Upper German and some Middle German dialects, and the shift from *b > *p* and *g > *k* is limited to Upper German, though *b and *g are not always shifted word-medially in Alemannic (ibid.). Davis et al. (1999) and Iverson & Salmons (2003a) argue that the *Medienverschiebung* is a drag chain shift, with the shift of *t > /t͜s/ in the *Tenuesverschiebung* leaving a gap that was then filled by the shift of *d > /t/ in most of the High German dialects; they also argue that the shift of the coronal stops is most widespread because they are the least marked, with labials being more marked, and velars the most marked (and shifted the least).

Evidence for this shift comes from OHG orthography. Braune (2004:88) states that Alemannic often has <b> where OS has *ƀ*, but Bavarian has <p>: OS *gëƀan*, Alem. *g-/keban*, Bav. *kepan* 'to give'. However, Braune (ibid.) also notes that the use of <b, g> in Old Alemannic orthography may be due to influence from Franconian orthographic conventions, so it is possible that these segments were realized as fortis in Alemannic to a greater extent than the orthography might indicate. He argues (ibid.) that the use of both <p, b> and <k, g> suggests that the labial and velar stops were at least voiceless in Upper German even if the shift to /p, k/ was incomplete. Braune (2004:89) argues that in Old Upper German, there was only a lenis/fortis distinction for /d/~/t/ (due to the *Spirantenschwächung*, see below) and that the labial and velar stops were written as either lenis or fortis, with the fortis representation more common word-initially.

5.2.4. The *Spirantenschwächung* ('Spirant Lenition')

According to Braune (2004:104), WGmc fricatives **f*, **þ*, **s*, **χ* underwent a lenition in word-initial and intervocalic position starting in the mid-8th century. This is reflected orthographically for **f* as <v, u> and for **þ* as (progressively) <th, dh, d>. The /d/~/t/ distinction in Upper German is therefore due to the shift of WGmc *þ > /ð/ > /d/; thus WGmc *þ > Upper German /d/ and WGmc *d > Upper German /t/ (examples from Ringe 2006:115, 138):

3) PGmc **duhtēr* > OHG *tohter* 'daughter' (*d > t)

PGmc **þankijan* > OHG *denchen* 'to think' (*þ > d)

The lenition of **χ* to /h/ had already taken place, but /h/ was then lost in OHG word-initially before sonorants (*hl*-, *hn*-, *hr*-, *hw*-) and occasionally intervocalically. The lenition of **s* was not reflected orthographically, but evidence from OHG borrowings into Slavic suggests it took place (Braune 2004:104). Braune (2004:130-133) states that WGmc **f* is always <f> word-finally, in clusters, and as geminate <ff> and that OHG /f, ff/ from WGmc *p is almost never written <v, u>, indicating that spirant lenition did not affect it and that there may have been a phonetic difference between the inherited WGmc fricatives and the fricatives that resulted from the High German Consonant Shift. Braune (2004:104) posits a voiceless, lenis realization of original WGmc fricatives as [v̥, z̥, x] in the modern Upper German dialects.

5.2.5. Notker's Law of Initials

Support for the view that all obstruents were phonetically voiceless in Upper German, specifically Alemannic, comes from *Notkers Anlautgesetz* ('Notker's Law of Initials'). Notker was an 11th century writer in St. Gallen (present-day northeastern Switzerland) who wrote in Alemannic (Braune 2004:2-3). In his writings, word-initial <b, d, g> alternate with <p, t, k> such that <b, d, g> appear after vowels and sonorants, and <p, t, k> appear 1) at the beginning of a phrase and 2) after obstruents, whether lenis or fortis; <v> also alternates with <f> but with less regularity, tending towards <f> even after sonorants (Braune 2004:105-106). Braune (ibid.) adds, however, that only /d/ < *þ participates in this alternation; WGmc *d/ð > /t/ is consistently <t> regardless of the phonetic voicing of the preceding segment.

This evidence supports the analysis that Upper German lenis obstruents were phonetically voiceless and that the only lenis/fortis distinction in Upper German was /d/~/t/. By the end of the OHG period, the Upper German obstruent inventory could be represented as follows (based on Moulton 1969:255-257):[67]

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[67] Here, I am abstracting away from the opposition between WGmc *t > OHG *ʒʒ* and WGmc *s(s) > OHG *s(s)*; these sounds merged in most dialects during the MHG period (Paul 2007:169-170) but in the Walliser and Walser dialects of Highest Alemannic, *s > /ʃ/ (Hotzenköcherle 1984:159-160, Karte 53).

labial			coronal			dorsal		
initial	medial	final	initial	medial	final	initial	medial	final
b/p-	-b/p-	-b/p	d-	-d-	-d	g/k-	-g/k-	-g/k
	-pp-	(-pp)	t-	-t-/-tt-	-t(/-tt)		-kk-	(-kk)
p͜f-	-p͜f-	-p͜f	t͜s-	-t͜s-	-t͜s	k͜x-	-k͜x-	-k͜x
f-	-f-		s-	-s-		x-	-x-	
	-ff-	-f(/-ff)		-ss-	-s(/-ss)		-xx-	-x(/-xx)

Table 5.2 Late Old Upper German obstruent inventory, based on Moulton (1969:255-257)

Moulton does not posit word-final geminates, but I add them here in parentheses because of descriptions of modern dialects; Kraehenmann's (2003) results support a word-final singleton/geminate distinction for stops and fricatives in Thurgovian Swiss German, and Ham (1998) shows that there are word-final geminate stops and fricatives in Bernese Swiss German. Although there is no length distinction posited for affricates here, Braune notes that there is occasionally some orthographic evidence in OHG texts for a difference in WGmc *p~*pp > /p͜f~p͜f:/ (2004:124-125), WGmc *t~*tt > /t͜s~t͜s:/ (2004:152-154), and WGmc *k~*kk > /k͜x~k͜x:/ (2004:136-138).

5.2.6. Middle High German

A few additional changes occurred in the Middle High German (MHG) period (1050-1350 CE; Paul 2007:10). One change is that of /s/ > /ʃ/ in clusters with /p, t, k, l, m, n, ʋ/, which was eventually reflected in the orthography as <sch> (except in /sp/ and /st/ clusters, which remain

<sp>, <st>) (Paul 2007:169-175).[68] In the case of /sk/ clusters, the /k/ is no longer pronounced, and the entire cluster becomes /ʃ/; thus /s/ and /ʃ/ become contrastive in prevocalic position: MHG *sîn* 'his', *schîn* 'shine' (Paul 2007:171). Additionally, Paul (2007:156) states that in High Alemannic, initial affricate /k͜x/ shifts to a simple fricative /x/ in the 10th century; and sometime between MHG and modern German, the labial fricatives /v/ (< *f) and /f/ (< *p) merge to /f/, and the glide /w/ becomes a voiced fricative /v/.

An additional change in Upper German is that by the MHG period, the effects of the *Medienverschiebung* remain for /t/ (< *d) and the geminates /pp, tt, kk/ (< *bb, *dd, *gg,) but the labial and velar singleton stops are once again /b/ and /g/ (< *b, *g) (Paul 2007:118). Paul (2007:150-151) and Braune (2004:127-128) both note that because of this change, singleton /p/ only appears word-initially and word-medially in Upper MHG in loanwords because it otherwise became /ff/ or /pf/ as a result of the High German Consonant Shift, but the orthographic representations also suggest that loanwords were often simply adopted into the phonology as having /b/, written <b>, especially in Upper German (examples from both Paul and Braune):

4) *pâbes/bâbes* 'Pope'
predigōn/brëdigôn 'to preach'

Moulton (1969:256) suggests that both Notker's Law as well as loanwords may have played a role in the development of a singleton lenis/fortis contrast, but also proposes for "extreme southern dialects" (citing Zürich German) that later changes like vowel syncope and consonant assimilation may have contributed (Moulton's examples; Standard German equivalents in italics):

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[68] Paul (2007:174) states that the <sch> orthography likely reflects an intermediate [sx]/[sç] pronunciation (similar to Modern Dutch).

5) /bində/ *binden* ‘to bind’; /pundə/ *gebunden* ‘bound’
/gaː/ *gehen* ‘to go’; /kaŋə/ *gegangen* ‘gone’
/boːnə/ *Bohnen* ‘beans’; /poːnə/ *die Bohnen* ‘the beans’
/gæiss/ *Geiss* ‘goat’; /kæiss/ *die Geiss* ‘the goat’

In the first two examples, the past participle prefix *ge-* undergoes vowel syncope to *g-* and then assimilates to the following stem-initial obstruent (e.g. *gebunde* → *gbunde* → /pundə/); in the second two examples, the same process occurs for the feminine definite article *die* → *d*, followed by assimilation (e.g. *die Bohne* → *d Bohne* → /poːnə/).

Kraehenmann (2003:64-65) argues specifically for the introduction of loanwords as the source for the (reintroduction of a) lenis/fortis distinction in Upper German, citing examples such as Low German *sta/p/el* ‘pile’ > *Sta/pp/el*, Middle French *câ/b/le* ‘rope’ > *Ka/p/el*; Old French *ma/t/* ‘exhausted’ > *ma/tt/*, French *fa/d/e* ‘tasteless’ > *fa/t/*. Since there was no native word-initial contrast, however, speakers had to decide how to handle word-initial */p/alast* ‘palace’ vs. */b/allast* ‘weight’; according to Kraehenmann, speakers chose to adapt them to the native system, where a singleton/geminate contrast existed in medial and final positions, so they now have */pp/alast* and */p/alast*, respectively. Kraehenmann explains that “[t]o use a length contrast for initial voiceless stops meant that the speakers were not using the pure phonetic length, but creating an underlying phonemic contrast” (2003:65).

Considering these changes, it is perhaps unsurprising that the LENIS/FORTIS distinction in modern Swiss German obstruents is based on duration rather than voicing or aspiration. After the High German Consonant Shift took place, the obstruent inventory consisted of stops, fricatives, and affricates, and likely only a lenis/fortis distinction for /d/~/t/, though a non-initial singleton/geminate contrast was already in place. The changes outlined above thus profoundly altered the obstruent system of High German (especially Upper German) compared to the rest of WGmc and NGmc.

5.3. Modern Swiss German phonetics and phonology

5.3.1. Consonant inventory

Table 5.3 represents the consonant phoneme inventory proposed for Bernese by Ham (1998:60; cf. Marti 1985:25), with orthographic representations in angle brackets. Notice that there is very little difference between this and Paul's (2007:141) inventory for Upper MHG, including the three-way distinctions in the stops and fricatives. The main differences are that Paul does not recognize any length distinctions for the affricates and that in MHG, [ŋ] appeared as an allophone of /n/ in /ng/ clusters as [ŋg], but in Bernese, /ng/ clusters are realized as [ŋː]. Otherwise, there is apparently little difference between modern Bernese and Upper MHG.

	labial	alveolar	post-alv.	palatal	velar	lab.vel.	glottal
stops	b̥ <b>	d̥ <d>			g̊ <g>		
	p <p>	t <t>			k <gg>		
	pː <pp>	tː <tt>			kː <gg>		
fricatives	v̥ <f, v>	z̥ <s>					h
	f <f(f)>	s <s(s)>	ʃ <sch>		x <ch>		
	fː <ff>	sː <ss>	ʃː <sch>		xː <ch>		
affricates	p͜f <pf>	t͜s <z>	t͜ʃ <tsch>		k͜x <k>		
	p͜fː <pf>	t͜sː <tz>	t͜ʃː <tsch>		k͜xː <ck>		
nasals	m <m>	n <n>					
	m: <mm>	nː <nn>			ŋː <ng>		
trills		r <r>					
laterals		l <l>					
glides	ʋ <w>			j <j>		[w] <l>	
						[wː] <ll>	

Table 5.3 Bernese consonant inventory, based on Ham (1998:60)

Before we turn our attention to the obstruents, some remarks on the other segments in the inventory are in order. Similar to the languages discussed thus far, /h/ does not participate in any of the alternations discussed here and has no further relevance; the palatal glide /j/ is also of little interest here. A characteristic of Bernese is that /l/ is realized as [l] in onset only, but is vocalized to [w] (written <u>) in coda position; long /lː/ does not occur word-initially and is thus always realized as [wː] even if it forms both coda and onset: *chralle* [xrɑwːə] 'claw' (Marti 1985:55-58). Ham (1998:61) also explains that /ŋː/ "is always comparable in duration to other geminate nasals" because it arose historically from /ng/ sequences. However, another characteristic of Bernese is that in many cases, /nd/ sequences are velarized to [ŋː]: *hung* 'dog'; cf. Standard German *Hund* (Marti 1985:35-36).

Stops:

Marti (1985:25, f.n. 4) states that for the LENIS stops, "Stimmhaftigkeit kann gelegentlich auftreten, gehört aber nicht zum Lautsystem" ["voicing can occasionally occur, but is not a part of the sound system"], and that the FORTIS stops are unaspirated (aside from a few loanwords from Standard German; 1985:32-33). However, he also mentions (1985:26) that in several northern Bernese dialects, word-initial /p, t, k/ merge with /b̥, d̥, g̊/ while in other southern Bernese dialects, word-initial /b̥, d̥, g̊/ merge with /p, t, k/; in other words, northern dialects tend to neutralize the LENIS/FORTIS contrast to LENIS and southern dialects tend to neutralize the contrast to FORTIS. Furthermore, Marti (1985:33) explains that in certain areas, "je nach Sprechsituation kann man starke oder weiche Verschlusslaute in praktisch allen Stärkegraden hören" ["depending on the speaking situation, one can hear strong (i.e. FORTIS) or weak (i.e. LENIS) stops in practically all degrees of strength"], and later (1985:36) gives examples of apparent free variation word-initially (*Beeri*/*Peeri* 'berry'; *Dinte*/*Tinte* 'ink') but not medially (*suber* 'clean'; *super* 'id.'). Thus in addition to regional variation, there is also individual variation in terms of maintaining a LENIS/FORTIS distinction for the stops.

As Ham (1998:60) explains, singleton /k/ (orthographic <gg>) is generally restricted to non-initial environments, but it does occur word-initially in some derived environments, such as perfective verbs and comitative nouns (both of which use a /g̊-/ prefix, e.g. Moulton's examples cited above:/gaː/ *gehen* ‘to go’; /kaŋə/ *gegangen* ‘gone’) and in French loanwords beginning in /k/ (Fr. *café*, Sw. Ger. *Ggaffe*; Ham’s examples). This means that word-initially, /p/ and /t/ occur more frequently than /k/ and the inventory is somewhat asymmetrical for the velars.

Ham (1998:62-63) claims that the three-way distinction in the stop series can be explained by the LENIS stops being derived from WGmc voiced fricatives, the FORTIS stops from WGmc voiced stops, and the geminate FORTIS stops from WGmc geminate voiced stops:

6) WGmc *ƀ, *ð, *g̱ > South Alem. /b̥, d̥, g̊/
WGmc *b, *d, *g > Alem. /p, t, k/
WGmc *bb, *dd, *gg > Alem. /pː, tː, kː/

As discussed above, WGmc voiced obstruents had spirantized allophones that had varying distributions (Braune 2004:81-82); Ham is arguing that these spirantized allophones are the source for Alemannic /b̥, d̥, g̊/. I am hesitant to fully accept this proposal due to the widespread agreement not only that the WGmc stops *b, *d, *g and spirants *ƀ, *ð, *g̱ were in complementary distribution, but also that the spirantized allophones were lost early in Upper German, before OHG, and that even if WGmc *b shifted to /p/ in Alemannic, it returned to /b/ by the end of the OHG period (see discussion and references above).

Ham’s results (discussed below) clearly show that this three-way distinction in Bernese exists (at least at the surface level), but as noted above, both Braune (2004) and Paul (2007) state that the primary source for /p/ in OHG or MHG was from loanwords. Although neither Braune nor Paul discuss /k/, it is presumably also mainly from loanwords (which Ham does mention), possibly from French or perhaps even unshifted Middle or Low German. Marti (1985:33) notes that loanwords from Standard German with aspirated /k/ are realized with an affricate /k͜x/ (*Krach* [k͜x-] ‘noise’) whereas recent loanwords with aspirated /p/ or /t/ are often (but not always) aspirated (*Pack* [p^{h}ɑk͜x] ‘package’, *Tärmometer* [t^{h}-] ‘thermometer’; but *Pulver* [p-] ‘powder’, *Tubak* [t-] ‘tobacco’). Marti (1985:40) also explains that it is difficult to find minimal pairs for /g/ <g> and /k/ <gg> because WGmc *k shifted to /k͜x/ and subsequently to /x/, with /k/ in loanwords often becoming /k͜x/. It seems clear in any case that the Bernese /b̥, d̥, ɡ̊/~/p, t, k/ distinction is not derived from the WGmc voiced obstruents and their stop/spirant allophones.

Furthermore, Fleischer & Schmid (2006:246) state the following concerning the inventory of Zürich German, though it also applies to Swiss German generally:

> With regard to FORTIS plosives and affricates, the core lexicon exhibits a structural asymmetry for velars: the phonemes /k/ and /k͜x/ appear mainly in word-internal and word-final contexts, as in [ˈhɒːkə] ‘hook’ (n), [ˈhɒk͜xə] ‘to hack’ and [ʒ̊næk] ‘snail’, [d̥ræk͜x] ‘dirt’. Historically, this state of affairs is due to the fact that the initial Germanic **k*- in High Alemannic (as opposed to most other High German dialects) was affected by the Old High German sound shift, originally giving rise to an initial velar affricate that was eventually simplified to a fricative, yielding, for instance, [ɣ̊ind̥] ‘child’ (cf. Standard German *Kind*). The phonemes /k/ and /k͜x/ may occur word-initially, but in native items only as instantiations of morphologically conditioned fortition, e.g. [k͜xæu̯ft] ‘bought’ as opposed to [ˈɣ̊æu̯fə] ‘to buy’ or [kɛː] ‘given’ as opposed to [ɡ̊ɛː] ‘to give’ (perceptually, the contrast is more salient in the prefixed forms [ˈɒːɡ̊ɛː] ‘to state’ as opposed to [ˈɒːkɛː] ‘stated’). Morphologically underived word-initial [k] appears in French and English loanwords (e.g. [ˈkʊɒføːr] ‘hairdresser’, cf. French *coiffeur*, [kɒːr] ‘coach’ (n), cf. English

car), while word-initial [k͜x] is typical of quite a number of loanwords from Standard German (e.g. [k͜xɒmp͜f] 'fight', cf. Standard German *Kampf*) and a few – presumably recent – borrowings from English, such as [k͜xuːl] 'cool (figurative sense)'.

This is additional evidence for the role of loanwords in the inventory as well as the asymmetrical velar series.[69]

Fricatives:

Ham (1998:62) notes that the three-way distinction for the fricatives only occurs in word-medial position and is limited to /f/ and /s/; /ʃ/ and /x/ only have a singleton/geminate contrast. He provides the following historical source for the three-way contrast in Bernese fricatives (1998:64):

7) WGmc *f, *s > OHG v, z > Alem. v̥, z̥ (spirant lenition)
WGmc *p, *t, *k > OHG/MHG f(f), s(s), x(s) > Alem. f, s, x (Vː___V, ___#)
WGmc *p, *t, *k > OHG/MHG ff, ss, xx > Alem. fː, sː, xː (V___V)
WGmc *k > OHG kx > South Alem. x (#___)
WGmc *sk > OHG sk > MHG ʃ > Alem. ʃ (#___, Vː___), ʃː (V___)

In this case, the combination of spirant lenition of original WGmc fricatives *f and *s in word-initial and intervocalic position (Braune 2004:104), along with the development of new fricatives from the High German Consonant Shift, results in a LENIS/FORTIS contrast, and the length contrast is the result of differences in vowel length (in which case, the length contrast could be analyzed as conditioned rather than phonemic, which I argue below). Notice that only the LENIS

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[69] Robert Howell (p.c.) points out that it is no simple matter to determine which Swiss German words are loanwords from Standard German, and that *kampf* apparently shows up in Old Alemannic texts from the 12th century.

fricatives appear word-initially, and the LENIS/FORTIS contrast obtains in medial and final position only.

Affricates:

In Table 5.3 above, Ham posits a length distinction for the affricates, but no LENIS/FORTIS distinction. Ham (1998:64-65) explains that the singleton/geminate distinction in the affricates arose from the singleton/geminate distinction in WGmc stops via the Second Consonant Shift:

8) WGmc *pʰ, *tʰ, *kʰ > Alem. p͜f, t͜s, k͜x (#___, ___#, C___)
WGmc *pʰː, *tʰː, *kʰː > Alem. p͜fː, t͜sː, k͜xː (medial, post-vocalic)

However, because of the complementary distribution of these affricates, it seems clear that any durational differences are to be analyzed as allophonic rather than phonemic, with long affricates limited to intervocalic position and short affricates occurring elsewhere. With the exception of /t͜ʃ/, the affricates derive historically from a single segment (either short or long), though this does not necessarily mean they are analyzed synchronically as such (see Lin 2011 for discussion). Recall also that although many instances of /k͜x/ shifted to /x/ in south Alemannic, there are also unshifted cases that may be found in loanwords (see above). The source of /t͜ʃ/ seems to be /t/ + /ʃ/ (e.g. OHG *diutisk* (Braune 2004:49) > MHG *tiutesch*/*tiutsch* (Paul 2007:111) 'of the people' ('*Deutsch*')) though it is also found in loanwords (*Tschechien* 'Czech Republic').[70] Marti (1985:70) adds that in Bernese, /t/ is sometimes simply inserted word-initially before /ʃ/ to become /t͜ʃ/ (*tschudere* 'to shudder'; cf. Standard German *schaudern*). Although not specifically discussed by Ham, the length distinction for /t͜ʃ/~/t͜ʃː/ is presumably also determined by the same environments as the other affricates.

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[70] Jessen (1998:3) also mentions the LENIS affricate /d͜ʒ/ but states that it only occurs in non-native vocabulary.

Marti (1985:22) notes that when the affricates are long or become lengthened, it is reflected orthographically only for /k͜x/ and /t͜s/ (<ck> and <tz>, respectively) but not for /p͜f/ or /t͜ʃ/ (this is also reflected in Table 5.3 above); this suggests that they may be analyzed as one segment rather than consecutive stop + fricative sequences. Hall (2012) finds that affricates pattern with fricatives in Cimbrian German, but stops short of positing a complete featural representation of affricates. Wiese (1996:41-42) treats affricates (in Standard German) as separate segments that share a skeletal position:

9)

Jessen (1998:3) states that “the majority of the phonological evidence speaks for the bisegmental status of /t͜ʃ/ and for the monosegmental status of only /p͜f/ and /t͜s/ in German” (/k͜x/ is not found in Standard German). However, it is of little importance for present purposes to decide whether there is any difference between /t͜ʃ/ and the other affricates, so I assume that all Bernese affricates are monosegmental.

5.3.2. Fortition/assimilation

Marti (1985:67) describes several fortition processes in Bernese, most of which can be analyzed as assimilations:

10) *ab* + *bräche* → *appräche* ‘to break up/off’

chläbe ‘to stick’ + -*t* (3sg) → *chläpt*

rede ‘to speak’ + -*sch* (2sg) → *retsch* *schwyge* ‘to be silent’ + *-sch* (2sg) → *schwyggsch*

psteue ‘to order’ (cf. Standard German *bestellen*)

Ggwehr ‘weapon’ (cf. Standard German *Gewehr*)

ändlech → *äntlech* ‘finally’

These are analogous to assimilation processes in other languages, but may be difficult to test instrumentally; if all stops are voiceless, and segments tend to be shortened in clusters, then it may be difficult to determine based on acoustic measurements alone if fortition is taking place. Moulton (1986:386) notes that “the neutralized obstruents that appear [in these fortition environments] are what Swiss phoneticians call ‘half fortis’,” which suggests an incomplete neutralization.

5.3.3. Phonetic Studies of Swiss German Dialects

In other studies of Swiss German dialects, compared to Ham’s analysis, there is often only a two-way LENIS/FORTIS contrast for the obstruents. For example, Willi (1996) and Fleischer & Schmid (2006) posit a simple LENIS/FORTIS distinction for Zürich German stops (/b̥, d̥, g̊/~/p, t, k/) and fricatives (/v̥, z̥, ʒ̊, ɣ̊/~/f, s, ʃ, x/), but no length distinction for the affricates (/p͜f, t͜s, t͜ʃ, k͜x/). Kraehenmann (2003) and others posit a singleton/geminate contrast in order to account for the weight-bearing properties exhibited by FORTIS obstruents.

5.3.3.1. Fulop (1994)

Fulop’s study of the Zürich dialect compares LENIS and FORTIS stops in word-initial, word-medial, and word-final environments and finds no difference in VOT (he finds aspiration word-finally, but it is the same for LENIS and FORTIS stops) or voicing, but it does show differences in closure duration in medial and final position (FORTIS is longer) as well as differences in formants above F_2 (according to Fulop, FORTIS shows increased “intensity, movement, and clarity” compared to LENIS; 1994:60-61).

5.3.3.2. Willi (1996)

Willi examines intervocalic LENIS and FORTIS stops in Zürich German and finds that /p, t, k/ are 67% longer than /b̥, d̥, g̊/ (132 ms vs. 79 ms; 1996:147), and both long and short vowels can precede LENIS and FORTIS stops with only small differences in vowel or closure duration (1996:119), but the perception portion of his study shows that the relative duration of the preceding vowel plays a role in the LENIS/FORTIS distinction (1996:195).

5.3.3.3. Enstrom & Spörri-Bütler (1981)

Enstrom & Spörri-Bütler compare VOT in word-initial LENIS and FORTIS stops for five male speakers of Zürich German. Although they find some prevoicing for labial stops, they find no significant difference in positive VOT between LENIS and FORTIS stops at the same place of articulation. However, as found in numerous other studies, they find an increase in VOT from anterior to posterior places of articulation, with /b̥, p/ at 4.63 ms, /d̥, t/ at 14.74 ms, and /g̊, k/ at 26.74 ms.

5.3.3.4. Kraehenmann (2003)

Kraehenmann (2003:41) posits a two-way contrast for Thurgovian (eastern Switzerland), but instead of a LENIS/FORTIS contrast, she argues instead for a singleton/geminate contrast for the stops (/p, t, k/~/pː, tː, kː/) and fricatives (/f, s, ʃ, x/~/fː, sː, ʃː, xː/), but again, no length contrast for the affricates. Her results show no difference in VOT between singleton and geminate stops (2003:115) but statistically significant differences in closure duration between singleton and geminate stops in all word positions (2003:116), with slightly longer durations after short vowels than long vowels for both singletons and geminates (2003:118, 122, 127-128). However, she also notes that in word-initial position, there is considerable variation in the production of the singleton/geminate distinction, with some words being realized with a singleton stop by some speakers and with a geminate stop by other speakers (2003:129-133). Kraehenmann also measures fricatives and finds a singleton-geminate distinction medially and finally, but not initially (2003:144). Her results for fricatives are essentially the same as for stops, with geminate fricatives significantly longer than singletons both medially and finally, and slight differences for both singleton and geminate fricatives depending on the length of the preceding vowel (2003:145, 147). Kraehenmann finds similar results for medial and final singleton and geminate (nasal) sonorants (2003:155-163), though the length contrast for sonorants only surfaces after short vowels; she argues for different syllabification requirements for sonorants than obstruents, namely that sonorant geminates need to form part of the syllable nucleus (2003:156, 163-166).

5.3.3.5. Ham (1998)

In contrast to Zürich German and Thurgovian discussed above, Ham (1998:55-65) posits the following for Bernese (he describes the contrast in terms of “devoiced, voiceless, and geminate”; I use the terms LENIS, FORTIS, and geminate):

1) in word-initial position: a two-way length contrast for the stops, with a possible three-way contrast for the stops in assimilation environments

2) in word-medial position: a three-way length contrast for the stops and the fricatives /f/ and /s/, with a two-way length contrast for the affricates and the fricatives /ʃ/ and /x/
3) in word-final position: a three-way length contrast for the stops, a two-way contrast for the other obstruents

Ham (1998:66-67) notes furthermore the following distribution of short and long vowels/diphthongs:

11) distribution of short vowels:

CVDV	[b̥ɑd̥ə] ‘to go swimming’
CVTːV, CVTː	[hʏtːə] ‘Alpine hut’, [hʏtː] ‘today’
CVCCV, CVCC	[g̊ʊmpə] ‘to jump’, [g̊ʊmp] ‘jump’ (n.)

distribution of long vowels and diphthongs:

CVVDV, CVVD	[ɑːb̥ə] ‘evening’, [b̥ɑːd̥] ‘bath’
CVVTV, CVVT	[huːtə] ‘to skin’, [huːt] ‘skin’ (n.)

Ham explains that LENIS obstruents may be preceded by either long or short vowels, but in monosyllabic words, it must be a long vowel; FORTIS singletons must be preceded by a long vowel; and geminates (and clusters) must be preceded by a short vowel.

Ham’s experiments examine the speech production of three speakers of a dialect of Bernese (Grossaffoltern, ca. 25 km north-northwest of the city of Bern). He first examines word-medial and word-final stops, fricatives, and nasals, measuring closure duration, VOT, voice offset time, and the duration of the preceding vowel (1998:89-113); and also word-initial stops, measuring closure duration and VOT (1998:122-130). Statistically significant differences were found for closure duration in LENIS, FORTIS, and geminate stops word-medially (92 ms, 171 ms, and 259 ms, respectively; 1998:92, 270) and word-finally (102 ms, 172 ms, and 232 ms, respectively; 1998:93, 270), as well as fricatives (/f, s/ only) in word-medial position, though the differences were slightly smaller than for stops (1998:96, 278); a two-way (FORTIS/geminate) contrast was found for /f/ and /s/ word-finally (1998:97). Ham argues that these results indicate a three-way durational contrast in non-initial position for stops, and a three-way contrast medially and two-way contrast (FORTIS/geminate) finally for the fricatives /f, s/. Statistically significant differences in duration were found medially and finally for /ʃ, x/ (1998:98, 99) and the nasals /m, n/ (1998:100, 101). No statistically significant differences were found for VOT in medial position for the stops (1998:103-104); the same is generally true for voice offset time (1998:105-106). Similar results were found for voice offset time in fricatives (1998:107-109), with some speakers showing differences.

Ham's results for vowel length show only minor differences in long vowels preceding FORTIS singletons in either mono- or bisyllabic words, and the same is true for short vowels preceding FORTIS geminates in either mono- or bisyllabic words (1998:112-113), but vowel length increases before LENIS stops from short bisyllabic (CVDV; 107 ms), to long bisyllabic (CV:DV; 192 ms), to long monosyllabic (CV:D; ca. 240 ms) words (1998:110-111). Interestingly, short vowel duration is nearly identical in CVDV and CVT:V words (107 ms and 117 ms, respectively) and long vowel duration is nearly identical in CV:DV and CV:TV words (192 ms and 198 ms, respectively) (1998:270).

For word-initial stops, Ham compares present and perfective forms of verbs to determine if gemination is taking place. He finds that there is a difference in duration between LENIS present and perfective forms, and secondly that there is no difference between the perfective LENIS, present FORTIS, and perfective FORTIS (1998:124-126). Thus only LENIS stops are lengthened in the perfective, but they are lengthened to the same duration as a FORTIS stop, i.e. they become FORTIS; the distinction is effectively neutralized. Again, there is no difference in VOT for initial stops in Ham's results (1998:127-130). Ham (1998:137) also cites his own previous study (1997) in which F0 is measured following LENIS, FORTIS, and FORTIS geminate stops, and instead of finding an increase in F0 for FORTIS and FORTIS geminate stops, he finds a decrease, with F0 higher after LENIS stop. Ham generally argues against a traditional LENIS/FORTIS distinction on basis of his results, but the bulk of his argument against a LENIS/FORTIS distinction seems to be based on Marti's (1985) failure to account for the distribution of geminate stops and fricatives in Bernese; I continue to use the terms 'LENIS' and 'FORTIS' because I use a broad definition of these terms rather than attach any specific phonetic criteria. Additionally, as I argue below, a two-way LENIS/FORTIS (or singleton/geminate) analysis seems better equipped to account for the vowel length alternations in monosyllabic lengthening (MSL) and open syllable shortening (OSS) mentioned at the beginning of the chapter.

5.3.4. Vowel length and quantity[71]

Marti (1985) discusses vowel quantity in Bernese several times, but mainly in terms of its variability, both geographically and between speakers, and sometimes even for the same speaker; as a result, vowel length is often not reflected orthographically. He notes in particular (1985:26, Marti's transcriptions) that several northern Bernese dialects have a tendency to lengthen old

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[71] See also Hotzenköcherle (1986:319-333) for more discussion on vowel quantity in Swiss German generally.

short vowels (*Hase* → *Haase* ‘rabbit’; open syllable lengthening (OSL)) while some southern Bernese dialects tend to shorten old long vowels (*schrȳbe* → *schrybe* ‘to write’; open syllable shortening (OSS)); he later notes that OSS only occurs for high vowels before *s*, *b*, *d*, and *g* in polysyllabic words, and apparently also before *t* in both mono- and polysyllabic words: MHG *lût* > Bernese *lut* ‘loud’ (1985:46). However, this picture is somewhat incomplete.

Seiler (2005b) discusses OSS in Bernese, stating that it operates on a lexeme-by-lexeme basis, i.e. it is not a regular sound change. As Seiler explains, OSS is related to monosyllabic lengthening (MSL), where a minimal bimoraic word requirement lengthens the vowels of light stems: /CVD/ → [CVːD] (MHG /rad/ > Bernese [rɑːd̥] ‘wheel’; cf. MHG /re.dər/ > Bernese [re.d̥ər] with two light syllables); MSL also occurs in many other Upper German dialects (see also Page 2001). According to Seiler, OSS occurs when original long vowels are reanalyzed as underlyingly short (unspecified for length) and having undergone MSL: Bernese /huz̥/ → [huːz̥], [hʏ.z̥ər] ‘house’, ‘houses’; in reality, however, MSL never took place, and the stem vowel was originally long: MHG /huːs/, /hyː.sər/. Crucially, Seiler notes that OSS occurs before singleton (LENIS) obstruents and sonorants, but not before geminate (FORTIS) obstruents (Seiler’s examples and transcription):

12) a. Shortening:

MHG [bliː.bən] > Bernese [b̥lɪ.b̥ə] ‘to stay’

MHG [gnaː.dən] > Bernese [g̊nɑ.d̥ə] ‘graces’

MHG [stiː.gən] > Bernese [ʃtɪ.g̥ə] ‘to rise, climb’

MHG [viː.sən] > Bernese [vɪ.z̥ə] ‘to show, direct’

MHG [hoːx] > Bernese [hœːx], [hœ.xər] ‘high’, ‘higher’

MHG [muːl] > Bernese [muːl], [mʏ.lər] ‘mouth’, ‘mouths’

MHG [ɹ̯æː.rek] > Bernese [ɹ̯æ.rɪg̊] ‘a year old’

b. No shortening:

MHG [biːs.sən] > Bernese [b̥iːs.sə] ‘to bite’

(also: MHG *rîten* (Paul 2007:250) > Bernese *ryte* /iː/ ‘to ride’)

Based partially on this prosodic evidence, Ham (1998:59) argues for a three-way durational contrast in Bernese because monosyllabic words can only contain a short vowel if it is followed by a geminate consonant (or cluster); thus CVːD, CVːT, and CVTː (or CVCC) are all valid monosyllabic shapes, but *CVD, *CVT, and *CVːTː (or *CVːCC) are apparently not (1998:66-67). Following Ham’s logic, if there is only a two-way contrast between D and T, then there is no explanation for why MSL does not take place in CVTː words unless they are distinctive. Furthermore, he states that “vowel quantity in the default case is polarized as a function of the following obstruent type: short vowels precede [LENIS singleton; CVDV] and [FORTIS] geminate [CVTːV], and long vowels precede [FORTIS singleton; CVːTV]” (1998:70). Thus, according to Ham, there is a need for a three-way distinction between D, T, and Tː (or LENIS, FORTIS, and geminate) in order to explain the vowel length distribution.

However, Kraehenmann (2003) notes a similar pattern in Thurgovian Swiss German and argues based on phrase-prosodic evidence that all FORTIS stops (or geminates, in her two-way singleton/geminate analysis) are phonologically long and (depending on syllabification) weight bearing. Page (2001), Kraehenmann (2003), and Seiler (2005a, b) all propose that in Alemannic, both vowel and consonant length are contrastive, and that long vowels are bimoraic (µµ), short vowels and geminate consonants are monomoraic (μ), and singleton consonants are weightless (see also Hayes 1989). This means that CV:T words carry three moras (they are superheavy) while CV:D and CVT words carry two and therefore meet the bimoraic minimum requirement.

It is worth noting that in Kraehenmann's (2003:118) results for word-medial stops in Thurgovian, there is only a 10 ms difference between the medial stops in *huupä* 'to honk' (160.9 ms) and *Suppe* 'soup' (170.6 ms); these results compare to Ham's (1998:92) results for medial singleton FORTIS stops (ca. 160 ms, preceded by a long vowel or diphthong; CVVTV), but his results for medial geminates (preceded by a short vowel; CVT:V) are more than 60 ms longer, starting at 220 ms. Additionally, Kraehenmann (2003:127-128) finds a 35.5 ms difference in closure duration in word-final position following long vs. short vowels (*Tat* 'deed' with a long vowel, *nett* 'nice' with a short vowel) while Schmid (2004:109) finds no word-final durational difference in Zürich German (*Beet* 'garden bed' with a long vowel, *Bett* 'bed' with a short vowel); the difference is closer to 80 ms in word-final position for two of Ham's Bernese speakers (1998:93). A possible interpretation of these results is that the contrast is truly only LENIS/FORTIS (or, in Kraehenmann's terms, singleton/geminate) in both dialects, but that the vowel-to-consonant ratio is different in each dialect. It may be significant that Seiler (2005b) argues that in Bernese, vowel length is contrastive, and long vowels are specified for length but short vowels are underspecified; if this is the case, then the longer closure duration in stops following short (unspecified) vowels and shorter closure duration following long vowels may act as a phonetic (durational) enhancement of the vowel length contrast.

5.4. Experimental data

5.4.1. Methodology

The same basic procedure was followed here as with the experiments in the previous chapters. As with the wordlists for Norwegian and Dutch in the previous chapters, the wordlist for Swiss German consists of real words[72] with word-initial obstruents and obstruent-sonorant clusters, followed by a vowel, which is in turn followed by a voiceless consonant or consonant cluster (CVCCV(C), CLVCCV(C)). The *Berndeutsches Wörterbuch* (von Greyerz & Bietenhard 1997) was the primary source for the items in the wordlist, though a few additional words were collected from Swiss German-speaking colleagues or Swiss German media sources. Where possible, the vowel is short and the medial consonant is long, but there is considerable variation in vowel length, even within the Bernese-speaking area, and vowel length is not predictable as it is in Dutch and Norwegian; in Bernese, long vowels can occur before geminate consonants and short vowels can occur before singleton consonants (see Marti 1985:19-20). For the most part, consonant length is reflected orthographically (e.g. /fː/ = <ff>) with the exception of /x/~/xː/ and /ʃ/~/ʃː/ which are written <ch> and <sch> respectively, regardless of length (Marti 1985:21).

Although many of the target words in the wordlist are possibly Standard German loanwords, I did not include word initial /k/ <gg> because, as explained above, it is found either in French loanwords with (unaspirated) /k/ or as the collective or past participle /g̊-/ prefix in native words. There are few non-derived <gg-> words, and even fewer in clusters with sonorants; it would be possible to find derived <gg> + sonorant clusters, but I chose to avoid this complication of

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[72] Some of the words in the list are undoubtedly loanwords, but they are not listed as such in von Greyerz & Bietenhard's *Berndeutsches Wörterbuch* (Bernese dictionary) and are likely perceived by speakers as native or nativized. I avoided recent loanwords whenever possible, though I did include *packe* 'to pack' to test for aspiration, since Marti (1985) specifically mentions that word as having aspiration for native Bernese speakers.

having one and only one stop category be derived while the others are non-derived. As a result, there is only one velar stop in this experiment, /g̊/. This is similar to Dutch in the previous chapter, but in Swiss German, WGmc *k has become a fricative /x/, whereas in Dutch, it is WGmc *g that has become a fricative /x/. Additionally, word-initial /t͜ʃ-/ was not included because it, unlike the other affricates, does not combine with sonorants in word-initial position. However, some comments will be made on both /k/ and /t͜ʃ/ in other environments that occurred in the wordlist.

The same basic procedures were followed for Bernese as for Dutch and Norwegian in the previous chapters. Speakers were asked to read a wordlist, with each word in a carrier phrase (*si het ömu* ____ *gseit* ‘she said (intensifier) ___’), and distractors were interspersed at fairly regular intervals in the word list to minimize speaker fatigue. In this case, word-initial stops, fricatives, and affricates, both bare and in obstruent-sonorant clusters, were the focus of the investigation.

The speakers were recorded in a home in Oberulmiz, approximately 10km south of Bern, where many of the speakers grew up, though a few speakers are from the nearby Liebefeld/Köniz area, which could be considered a southwestern suburb of Bern, and one speaker is from Bümpliz, just west of the Liebefeld/Köniz area. Ten speakers were recorded, but the recordings of two speakers were not included due to problems with the recordings. The eight speakers included here consist of four females and four males, six of whom are between 20 and 50 years old, though two older speakers (68 and 80 years old) were also included.

Some schwa epenthesis was observed in stop + /r/ clusters (/r/ is typically an alveolar tap or occasionally a trill), though as we will see, this did not cause any problems with the analysis due to the short VOT durations.

5.5. Results

5.5.1. Stops

5.5.1.1 Closure duration

		bare	/l/	/n/	/r/
b̥		/b̥-/	/b̥l-/		/b̥r-/
	mean	96.01	90.00		91.43
	st. dev.	37.42	35.33		38.09
p		/p-/	/pl-/		/pr-/
	mean	142.78	126.94		124.85
	st. dev.	41.75	48.42		41.56
d̥		/d̥-/			/d̥r-/
	mean	91.70			78.27
	st. dev.	47.10			37.34
t		/t-/			/tr-/
	mean	145.49			129.35
	st. dev.	44.58			50.18
g		/g̊-/	/g̊l-/	/g̊n-/	/g̊r-/
	mean	94.56	79.28	105.69	91.04
	st. dev.	47.76	34.14	45.86	45.38

Table 5.4 Mean closure duration in ms for bare stops and stops in stop + sonorant clusters

Generally speaking, closure duration for LENIS stops is around 90-95 ms; the exceptions to this are the decreased closure durations in /g̊l-/ and /d̥r-/ clusters (just under 80 ms) and the increased closure duration in /g̊n-/ clusters (about 105 ms). Closure duration for bare FORTIS stops is around 145 ms, which lowers to 125-130 ms in clusters. The large standard deviations are due to inter-speaker differences in closure duration; some speakers held the closures longer than others.[73]

A two-way ANOVA, with the LENIS/FORTIS distinction and place of articulation (excluding velar) as independent variables, shows that only the LENIS/FORTIS distinction is statistically significant.

LENIS/FORTIS	F (1, 111) = 39.55	$p < 0.0001$	omega^2 = 0.25
Place	F (1, 111) = 0.01	$p = 0.9209$	n.s.
Both	F (1, 111) = 0.18	$p = 0.6726$	n.s.

Table 5.5 Two-way ANOVA for stop closure duration

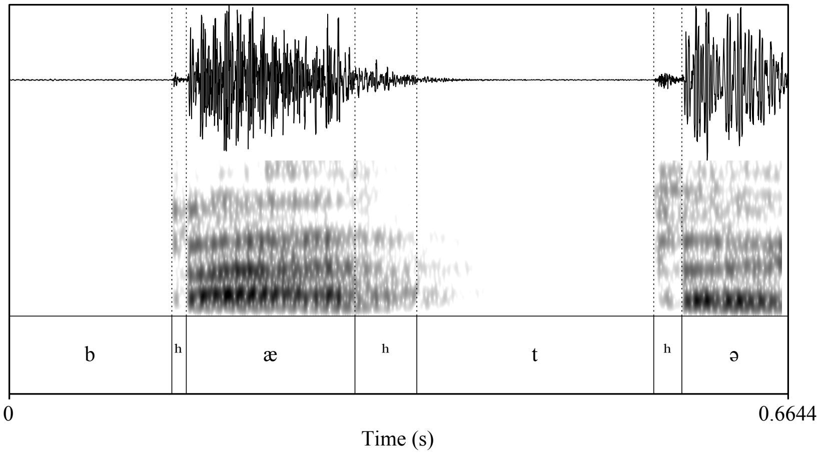

Figure 5.1 Token of *bätte* 'to pray' from speaker M1

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[73] One of the distractors in the wordlist, *göögge* 'to vomit', was consistently produced with a long closure duration for the initial /g̊/ (141.36 ms, s.d. 27.49) that is a good match for the other FORTIS obstruents and could be used to fill the FORTIS velar gap; it is unclear why this word was produced this way, so I chose to leave it out of these results.

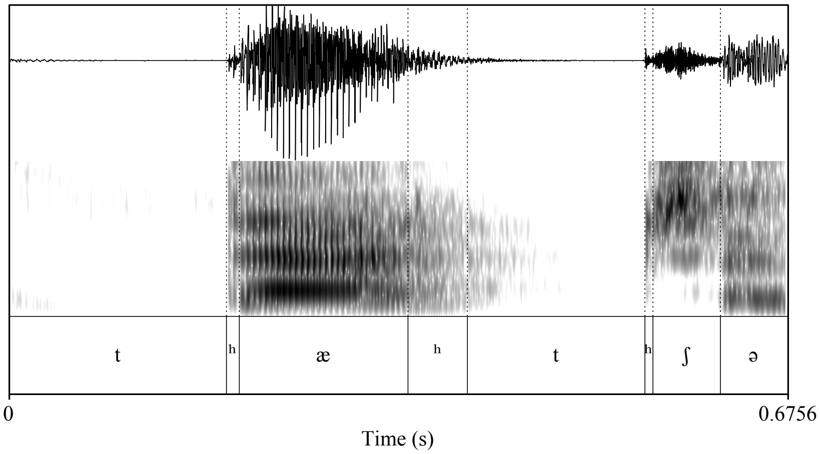

Figure 5.2 Token of *tätsche* 'to crack' from speaker F3

5.5.1.2. VoffT (pulsing duration)

LENIS	mean VoffT in ms	s.d.	FORTIS	mean VoffT in ms	s.d.
/b̥-/	41.92	25.32	/p-/	39.25	19.85
/d̥-/	40.75	17.99	/t-/	36.47	14.99
/g̊-/	44.60	22.55			
pooled	42.38	21.91	pooled	37.67	17.66

Table 5.6 Mean VoffT in ms for LENIS and FORTIS stops

The results for VoffT show that the LENIS stops have a slightly longer VoffT duration. A two-way ANOVA was run, with the LENIS/FORTIS distinction and place of articulation (except velar) as independent variables. The results for the ANOVA show that differences in VoffT are not significant for either LENIS/FORTIS or place.

LENIS/FORTIS	F (1, 111) = 0.99	$p = 0.3220$	n.s.
Place	F (1, 111) = 0.22	$p = 0.6413$	n.s.
Both	F (1, 111) = 0.00	-	-

Table 5.7 Two-way ANOVA for stop VoffT

VoffT in clusters is generally similar, though it does appear to be slightly lower for FORTIS stops compared to bare FORTIS stops above:

LENIS	mean VoffT in ms	s.d.	FORTIS	mean VoffT in ms	s.d.
/b̥l-/	34.65	16.80	/pl-/	29.84	11.14
/b̥r-/	40.38	19.72	/pr-/	29.65	13.81
/d̥r-/	35.20	14.98	/tr-/	28.64	16.15
/g̊l-/	36.06	20.34			
/g̊n-/	40.17	15.93			
/g̊r-/	42.28	21.72			

Table 5.8 Mean VoffT in ms for LENIS and FORTIS stop + sonorant clusters

Given the relatively large differences in closure duration and the relatively small differences in VoffT, % glottal pulsing would predictably show higher numbers for LENIS stops than FORTIS stops and would therefore be uninformative; I have chosen to omit this measure in the interest of space.

5.5.1.3. VOT

LENIS	mean VOT in ms	s.d.	FORTIS	mean VOT in ms	s.d.
/b̥-/	15.26	6.75	/p-/	16.63	3.90
/d̥-/	20.82	8.94	/t-/	18.71	5.06
pooled	18.09	8.36	pooled	18.00	4.76
/g̊-/	28.24	9.69			

Table 5.9 Mean VOT in ms for LENIS and FORTIS stops

Here we see some (expected) differences in VOT by place of articulation, but very little difference between LENIS and FORTIS stops. Unsurprisingly, a one-way ANOVA with LENIS/FORTIS (pooled labial and alveolar only) as the independent variable shows that the (very small) difference in VOT is not significant (F (1, 108) = 0.00; *p* = 0.9487).

In stop-sonorant clusters, we see a slight increase in VOT compared to bare stops, but still essentially no difference between LENIS and FORTIS stops.

LENIS	mean VOT in ms	s.d.	FORTIS	mean VOT in ms	s.d.
/b̥l-/	18.14	8.21	/pl-/	19.00	6.89
/b̥r-/	17.30	6.86	/pr-/	16.44	6.77
/d̥r-/	26.83	8.61	/tr-/	26.28	7.54
/g̊l-/	28.95	8.53			
/g̊n-/	65.72	21.43			
/g̊r-/	32.40	7.40			

Table 5.10 Mean VOT in ms for LENIS and FORTIS stop + sonorant clusters

Notice, however, that /gn-/ clusters show a dramatic increase in VOT. Further discussion of /g̊/ + nasal clusters follows below.

5.5.1.4. Sonorant duration

		bare	/b̥__/	/p__/	/d̥__/	/t__/	/g̊__/
l		/l-/	/b̥l-/	/pl-/			/g̊l-/
	mean	74.71	61.93	49.91			53.78
	st. dev.	21.21	22.48	15.70			20.73
m		/m-/					
	mean	84.87					
	st. dev.	18.21					
n		/n-/					/g̊n-/
	mean	77.14					74.25
	st. dev.	22.21					29.17
r		/r-/	/b̥r-/	/pr-/	/d̥r-/	/tr-/	/g̊r-/
	mean	51.76	39.15	41.94	41.16	44.19	39.57
	st. dev.	18.35	16.68	14.42	17.87	11.36	16.26
w		/ʋ-/					
	mean	88.20					
	st. dev.	29.24					

Table 5.11 Mean sonorant duration in ms for bare sonorants and sonorants in stop + sonorant clusters

With the exception of /g̊n-/, we generally see a decrease in sonorant duration in stop-sonorant clusters, as seen in the previous chapters.

5.5.1.5. Sonorant devoicing

There were only a few cases of discernible sonorant devoicing in stop-sonorant clusters, so it is simpler in this case to discuss those few cases where it did occur: Five cases of sonorant devoicing in /g̊n-/ clusters, from four different speakers, between about 15-30 ms; and two cases in /tr-/ clusters, from two different speakers, about 25 and 30 ms. Recall that in /g̊n-/ clusters, VOT increased to about 65 ms; it is perhaps surprising, therefore, that there aren't more cases of sonorant devoicing in /g̊n-/ clusters. Figure 5.3 illustrates a /pl-/ cluster with no sonorant devoicing, which is representative of the majority of the tokens.

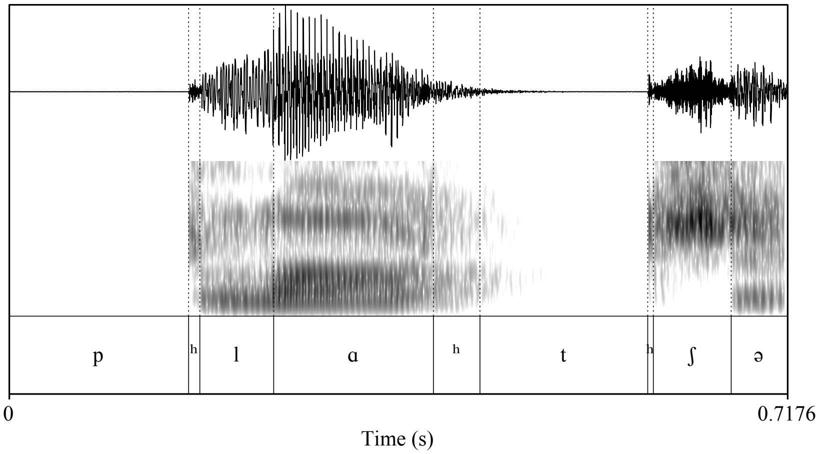

Figure 5.3 Token of *platsche* 'to splash, pour' from speaker F4

5.5.2. Fricatives

5.5.2.1. Fricative duration

		bare	/___l/	/___m/	/___n/	/___r/	/___ʋ/
<w>		/ʋ-/					
	mean	88.20					
	st. dev.	29.24					
<f>		/f-/	/fl-/			/fr-/	
	mean	136.26	127.27			123.17	
	st. dev.	35.48	30.22			26.92	
<s>		/s-/					
	mean	125.11					
	st. dev.	24.27					
<sch>		/ʃ-/	/ʃl-/	/ʃm-/	/ʃn-/	/ʃr-/	/ʃʋ-/
	mean	131.84	116.92	130.68	131.95	127.59	133.75
	st. dev.	30.78	26.05	27.52	31.90	26.07	31.34
<ch>		/x-/	/xl-/		/xn-/	/xr-/	
	mean	137.63	130.14		126.83	123.61	
	st. dev.	36.64	35.82		31.21	25.32	

Table 5.12 Mean fricative duration in ms for bare fricatives and fricatives in fricative + sonorant clusters

I have included /ʋ-/ as a fricative here for comparison, though it is generally described as a sonorant and is not mentioned in any of the Swiss German literature, as far as I am aware, as participating in any alternations with /f/; it also does not combine with sonorants word-initially. Recall also that WGmc *s shifted to /ʃ-/ in clusters; there are therefore no /s/ + sonorant clusters. The (voiceless) fricatives are all very similar in duration, with generally small decreases in duration in fricative-sonorant clusters. A one-way ANOVA was run for the bare fricatives (excluding /ʋ/), with place of articulation as the independent variable; no statistically significant difference was found for fricative duration (F (3, 122) = 0.98; *p* = 0.4052).

5.5.2.2. VoffT (pulsing duration)

bare	mean VoffT in ms	s.d.
/ʋ-/	88.20	29.24
/f-/	26.93	15.37
/s-/	23.50	11.60
/ʃ-/	20.74	15.53
/x-/	23.66	14.97

Table 5.13 Mean VoffT in ms for bare fricatives

Compared to the FORTIS stops, the fricatives have lower VoffT. Again, a one-way ANOVA was run for bare fricatives (excluding /ʋ/) with place of articulation as the independent variable; no statistically significant difference was found for VoffT (F (3, 122) = 0.95; *p* = 0.4172). Figures 5.4 and 5.5 show a word-initial /s/ and /x/, respectively, with very little voicing:

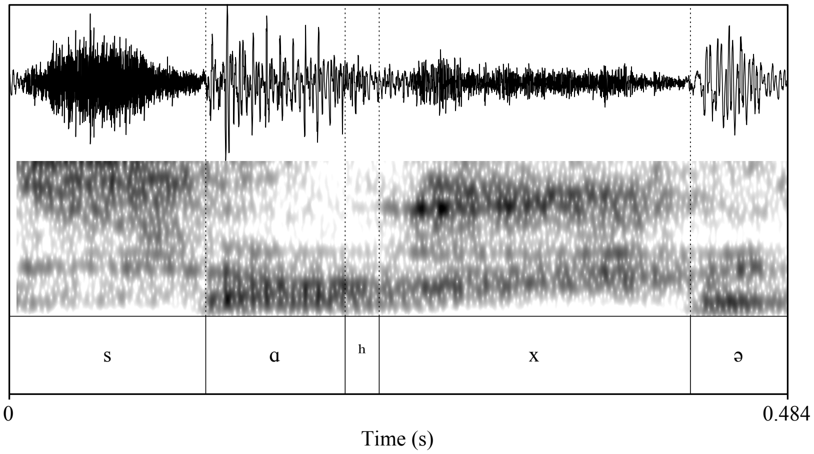

Figure 5.4 Token of *Sache* 'things, concerns' from speaker M3

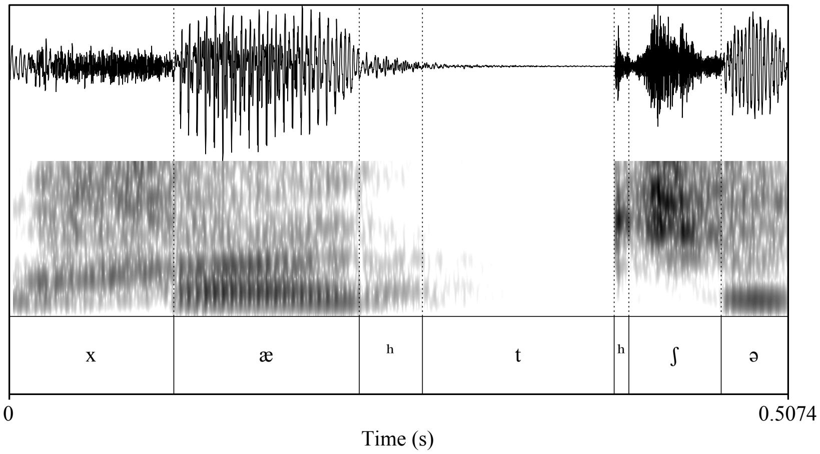

Figure 5.5 Token of *chätsche* ‘to chew’ from speaker F1

VoffT in fricative + sonorant clusters:

cluster	mean VoffT in ms	s.d.
/f-/	25.81	13.06
/ʃ-/	21.40	12.32
/x-/	32.40	22.02

Table 5.14 Mean VoffT in ms for fricatives in fricative + sonorant clusters

VoffT in fricative-sonorant clusters is very similar, with the exception of /x-/; one possible cause for this is that speaker F4 produced a lot of voicing in her /xn-/ clusters.

Again, with essentially no difference in either fricative duration of VoffT, any discussion of % glottal pulsing would be uninformative. It may be worth noting, however, that all speakers consistently produced /ʊ/ with 100% glottal pulsing.

5.5.2.3. Sonorant duration

		bare	/f__/	/ʃ__/	/x__/
l		/l-/	/fl-/	/ʃl-/	/xl-/
	mean	74.71	55.84	60.96	66.73
	st. dev.	21.21	18.58	21.59	25.58
m		/m-/		/ʃm-/	
	mean	84.87		66.28	
	st. dev.	18.21		16.51	
n		/n-/		/ʃn-/	/xn-/
	mean	77.14		64.14	74.87
	st. dev.	22.21		23.81	29.42
r		/r-/	/fr-/	/ʃr-/	/xr-/
	mean	51.76	42.62	49.41	45.13
	st. dev.	18.35	14.03	15.83	19.19
w		/ʋ-/		/ʃʋ-/	
	mean	88.20		66.59	
	st. dev.	29.24		22.21	

Table 5.15 Mean sonorant duration in ms for bare sonorants and sonorants in fricative + sonorant clusters

The main difference in sonorant duration after fricatives compared to stops is that /l/ is a bit longer; also note that /n/ in /xn-/ clusters is longer than other sonorants, similar to /gn-/ clusters above.

5.5.2.4. Fricative sonorant devoicing

There is generally very little sonorant devoicing observed in fricative + sonorant clusters, though in some cases, a bit more than was observed in stop + sonorant clusters. The results are displayed in Table 5.16:

	# son. dev.	range
/fl-/	1/32	20 ms
/fr-/	2/32	23-30 ms
/ʃl-/	9/32	15-35 ms
/ʃm-/	2/32	15-20 ms
/ʃn-/	1/48	15 ms
/ʃr-/	1/32	54 ms
/ʃʋ-/	17/32	10-30 ms
/xl-/	0/32	-
/xn-/	3/48	20-25 ms
/xr-/	0/32	-

Table 5.16 Number of fricative + sonorant tokens that exhibit sonorant devoicing, range of sonorant devoicing

The two categories that show the most sonorant devoicing are /ʃl-/ and /ʃʋ-/, with just over 25% of tokens in the former and just over 50% in the latter showing any sonorant devoicing; otherwise, only a handful of tokens show any sonorant devoicing. Figure 5.6 is a fairly representative example, showing a /ʃl-/ cluster with a fully voiced /l/.

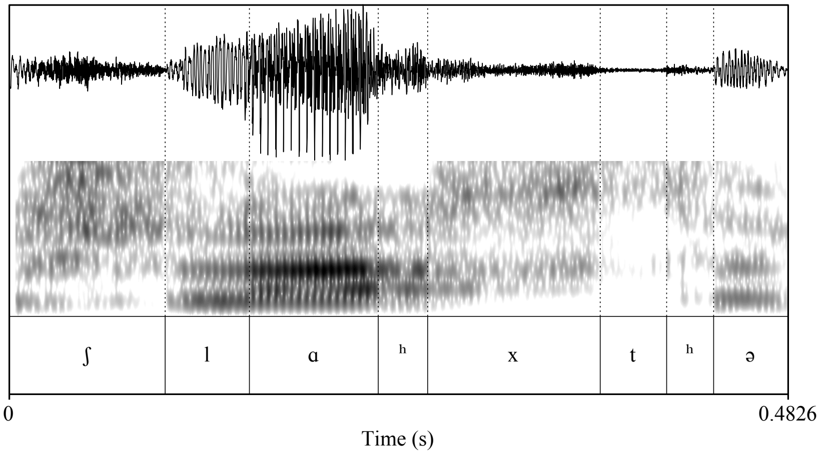

Figure 5.6 Token of *schlachte* 'to slaughter' from speaker F2

5.5.3. Affricates

It should be noted first of all that certain affricate + sonorant clusters are somewhat rare, particularly for /k͜x/, which has a tendency to be come /x/; indeed, a number of /k͜x/ + sonorant tokens were discarded because speakers simply produced them as [x]. The *Berndeutsches Wörterbuch* (von Greyerz & Bietenhard 1997) lists only two pages of entries for *k* (=/k͜x/) and very few of those are followed by sonorants; entries for *pf* are more numerous and include various combinations with sonorants, though /p͜fl-/ is by far the most common; there is no shortage of entries for *z* (=/t͜s/), but the only /t͜s/ + sonorant combination is /t͜sʋ/, which occurs quite frequently. Thus /p͜fn-/, /p͜fr-/, /k͜xn-/, and /k͜xr-/ each only have one representative in the wordlist instead of two.

5.5.3.1. Affricate closure/frication duration

Here, we examine both the closure and frication durations individually as well as the total duration of the affricate.

	closure		frication		total	
	mean	s.d.	mean	s.d.	mean	s.d.
/p͜f-/	120.35	54.68	71.59	24.59	191.94	56.57
/t͜s-/	104.17	46.24	86.72	24.44	190.89	50.15
/k͜x-/	107.80	41.61	87.91	20.39	195.71	50.45

Table 5.17 Mean closure and frication durations in ms for bare affricates

We see that although the closure duration is longer for /p͜f-/ than /t͜s-/ or /k͜x-/, the total duration for each affricate is strikingly similar, between 190-195 ms.

	closure		frication		total	
	mean	s.d.	mean	s.d.	mean	s.d.
/p͜fl-/	87.32	39.08	88.64	35.27	175.96	43.45
/p͜fn-/	89.89	38.07	118.06	21.99	207.95	47.35
/p͜fr-/	117.30	35.34	85.36	40.88	202.66	62.49
/t͜sʋ-/	82.71	33.60	96.64	26.69	179.34	44.08
/k͜xl-/	87.22	21.15	84.14	25.79	171.36	38.94
/k͜xn-/	86.24	29.59	94.17	18.40	180.40	37.19
/k͜xr-/	83.18	26.28	85.99	14.85	169.17	34.45

Table 5.18 Mean closure and frication durations in ms for affricates in affricate + sonorant clusters

Affricates in affricate + sonorant clusters are generally shorter than bare affricates, and it appears that closure duration is shortened (from 105-120 ms to 85-90 ms) while frication duration is actually lengthened somewhat. The outliers here are /p͜fn-/ and /p͜fr-/ clusters, which are considerably longer than the others; it may be relevant that these clusters occur rather infrequently. Figure 5.7 illustrates a typical velar affricate production.

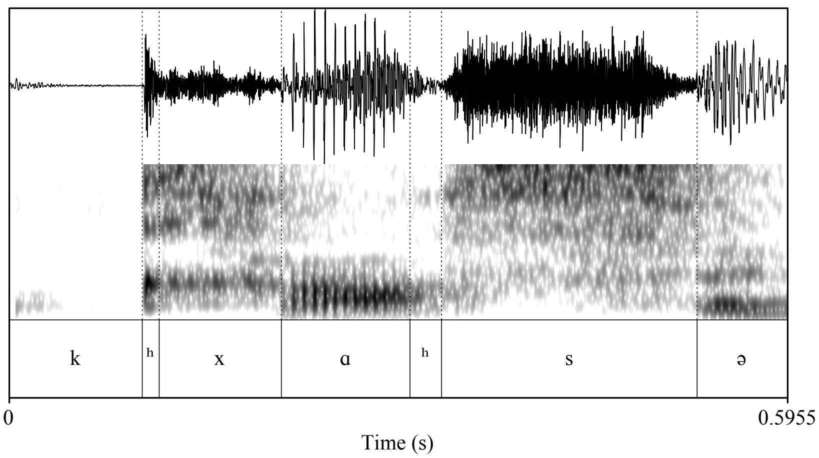

Figure 5.7 Token of *Kasse* 'till, cash box' from speaker M3

5.5.3.2. VoffT (pulsing duration)

	mean VoffT in ms	s.d.
/p͜f-/	31.46	24.03
/t͜s-/	26.87	17.24
/k͜x-/	29.35	12.79

Table 5.19 Mean VoffT in ms for bare affricates

The results for VoffT in affricates are similar to those for fricatives (20-28 ms) and slightly lower than those for stops (35-40 ms). The results for VoffT in affricate + sonorant clusters are essentially no different:

	mean VoffT in ms	s.d.
/p͜fl-/	33.04	16.73
/p͜fn-/	27.55	19.37
/p͜fr-/	27.83	16.25
/t͜sʋ-/	24.89	18.53
/k͜xl-/	25.28	11.69
/k͜xn-/	33.98	16.31
/k͜xr-/	32.58	17.66

Table 5.20 Mean VoffT in ms for affricates in affricate + sonorant clusters

5.5.3.3. Sonorant duration

		bare	/p͜f___/	/t͜s___/	/k͜x___/
l		/l-/	/p͜fl-/		/k͜xl-/
	mean	74.71	51.51		61.38
	st. dev.	21.21	16.88		19.84
m		/m-/			
	mean	84.87			
	st. dev.	18.21			
n		/n-/	/p͜fn-/		/k͜xn-/
	mean	77.14	63.32		69.28
	st. dev.	22.21	26.79		23.61
r		/r-/	/p͜fr-/		/k͜xr-/
	mean	51.76	43.54		41.85
	st. dev.	18.35	23.05		15.78
w		/ʋ-/		/t͜sʋ-/	
	mean	88.20		61.29	
	st. dev.	29.24		23.53	

Table 5.21 Mean sonorant duration in ms for bare sonorants and sonorants in affricate + sonorant clusters

Sonorant duration is shortened somewhat in affricate + sonorant clusters, as expected, but the durations are similar to those we have seen after stops and fricatives; again, velar + nasal clusters show the longest sonorant duration, similar to /gn-/ and /xn-/ above.

5.5.3.4. Affricate sonorant devoicing

Once again, there is very little sonorant devoicing. However, similar to /ʃʋ-/ clusters above, /t͜sʋ-/ clusters show the most sonorant devoicing, though in less than half of the tokens.

	# son. dev.	range
/p͜fl-/	3/31	15-20 ms
/p͜fn-/	1/16	15 ms
/p͜fr-/	0/16	-
/t͜sʋ-/	15/32	15-40 ms
/k͜xl-/	5/32	15-30 ms
/k͜xn-/	0/16	-
/k͜xr-/	2/32	35 ms

Table 5.22 Number of affricate + sonorant clusters that exhibit sonorant devoicing, range of sonorant devoicing

Figure 5.8 illustrates a /t͜sʋ-/ cluster with no sonorant devoicing:

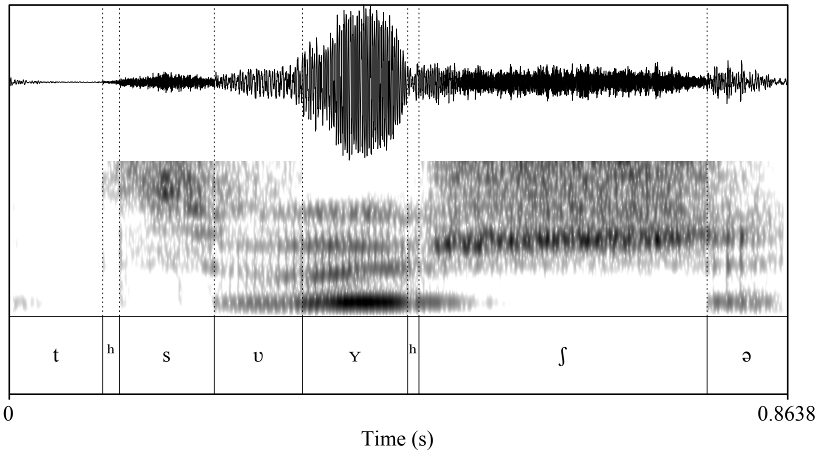

Figure 5.8 Token of *zwüsche* 'in between' from speaker M2

5.5.4. Assimilations/fortitions

A few of the distractors in the wordlist contained possible assimilation/fortition environments. Marti (1985:67) states that LENIS stops become FORTIS before other obstruents or as the prefix /g̊-/ (among other environments). Here are some results for the prefix /g̊-/:

12) *abeg<u>h</u>eie* 'to throw down/fall down': /g̊/ 96.61 ms (/h/ 80.35 ms)

<u>Gm</u>eind 'community': /g̊/ 95.86 ms (VOT 75.67 ms)

<u>Gn</u>osseschaft 'association': /g̊/ 93.10 ms (VOT 66.31 ms)

<u>Gs</u>undheit 'health': /g̊/ 84.01 ms

Compared to the word-initial results for bare /g̊/ above with a closure duration of 94.56 ms, there is very little difference for /g̊/ in any of these environments, with the exception of the long VOT values for /g̊/ + nasal clusters in *Gmeind* and *Gnosseschaft*. However, consider these examples comparing intervocalic /g̊/ to /g̊/ before word-final /t/ or /s/:

13) *ufestyge* ‘to climb up’: /g̊/ V___V 60.10 ms

nachegfragt ‘asked about’: /g̊/ ___/t/ 93.45 ms (participle prefix /g̊/ 83.32 ms)

ungerwaegs ‘on the way’: /g̊/ ___/s/ 83.70 ms

If intervocalic singleton /g̊/ is about 60 ms, then there could be an increase in duration for *nachefrage* ‘to ask about’ → *nachegfragt*, which could be seen as a case of fortition. VoffT is also approximately 30-35 ms in each of these cases, so there does not seem to be any difference in passive voicing.

On the other hand, /b̥/ in a pre-obstruent environment is actually shorter than word-initial bare /b̥/ (96.01 ms):

14) *ablade* ‘to unload’: /b̥/ ___/l/ 67.07 ms

Abstimmig ‘vote, poll’: /b̥/ ___/s/ 71.94 ms

Notice that there is very little difference between /b̥/ before a sonorant and /b̥/ before an obstruent (word-medial intervocalic /b̥/, as in *abegheie* above, is about 70 ms, as is the intervocalic /d̥/ in *ablade*). However, absolute word-final /b̥/ does appear to undergo fortition:

15) *näbenab* ‘astray, aside’: /b̥/ 127.18 ms (aspiration 52.00 ms)

Notice that this is considerably longer than word-initial /b̥/, it is closer in duration to word-initial /p/, and it is also followed by over 50 ms of aspiration. It is worth noting that there is also over 50 ms of aspiration at the end of *nachegfragt*, and also 40 ms of aspiration between segments in the /g̊t/ cluster: /g̊/ (93.45 ms) + aspiration (40.63 ms) + /t/ (72.42 ms) + aspiration (53.19 ms). This may be at odds with the results of Willi (1996) and Ham (1998) who find that the durational contrast is upheld in word-final position in other dialects of Swiss German.

5.5.5. Vowel length

Finally, considering the above discussion of Ham's (1998) distribution of short and long vowels before LENIS (VD), FORTIS (VVT), and FORTIS geminate (VT:) obstruents in Bernese, there is some evidence that, at least in this dialect of Bernese, long and short vowels can occur before long and short obstruents:

	vowel duration		obstruent duration	
	mean	s.d.	mean	s.d.
Huuffe 'heap, pile'	188.55 ms	44.46	188.50 ms	37.85
schnuufe 'to wheeze'	157.37 ms	56.80	116.52 ms	16.51
schaffe 'to work'	131.26 ms	32.53	210.63 ms	39.76
ufestyge 'to climb up'	84.83 ms	22.09	108.85 ms	19.74

Table 5.23 Comparison of long and short vowels before long and short /f/

Interestingly, the long vowel before the geminate (*Huuffe*) is longer than the long vowel before the singleton (*schnuufe*), and the short vowel before the geminate (*schaffe*) is longer than the short vowel before the singleton (*ufestyge*), though *ufestyge* has four syllables instead of two, which may shorten the vowel length (though /f/ is only 8 ms shorter in *ufestyge* than in *schnuufe*, which suggests a negligible effect on duration). Less surprising is that the geminate following the short vowel (*schaffe*) is longer than the geminate following the long vowel (*Huuffe*).

There are also examples of singleton/geminate /x/ in the wordlist:

	vowel duration		obstruent duration	
	mean	s.d.	mean	s.d.
Blache ‘large cloth cover’	106.78 ms	30.51	118.93 ms	17.13
bläche ‘to pay’	195.06 ms	57.81	114.85 ms	20.23
bräche ‘to break’	115.16 ms	28.84	202.43 ms	46.95

Table 5.24 Comparison of vowel duration before long and short /x/

In this case, vowel duration is similar for *Blache* and *bräche*, and obstruent duration is similar for *Blache* and *bläche*, but the long vowel is 80-90 ms longer than the short vowel and geminate /xː/ is about 85-90 ms longer than singleton /x/.

The above examples illustrate that in this dialect of Bernese, both long and short vowels can occur before both singleton and geminate obstruents. Ham (1998) uses vowel length as a diagnostic for the LENIS/FORTIS distinction in the dialect of Bernese he investigates, but that option is apparently not available for this dialect; neither is predictable from the other. However, the large standard deviations for the long vowels in *schnuufe* and *bläche* can be explained primarily by the results from two speakers: speaker F2 does not make a strong vowel length distinction (producing *schnuufe* with a short vowel; *Blache* and *bläche* vary), and speaker M2 makes an extremely robust vowel length distinction; interestingly, F2 is the youngest speaker and M2 is the oldest speaker. It is possible, then, that the younger speakers are beginning to shorten vowels before singleton LENIS obstruents, in which case there could be evidence that /f/ and /x/ are actually LENIS /v̥/ and /γ̊/, and probably also /s/ and /ʃ/ are LENIS /z̥/ and/ʒ̊/. All other speakers make a vowel length distinction in all of the examples above, though they differ from each other in duration.

Two other words in the wordlist for this experiment, *Schnägge* and *göögge*, provide a near-minimal pair to compare vowel quantity before a FORTIS stop:

	vowel duration		obstruent duration	
	mean	s.d.	mean	s.d.
Schnägge ‘snails’	106.24 ms	23.50	143.71 ms	53.81
göögge ‘to vomit’	192.69 ms	46.29	135.95 ms	40.61

Table 5.25 Comparison of vowel duration before a FORTIS stop

Here, there is a large difference in vowel duration but very little difference in stop closure duration. Recall that in Ham’s Bernese inventory in Table 5.3 above, both singleton /k/ and geminate /kː/ are represented orthographically as <gg>; it appears in this case that the medial stop is simply FORTIS, with no durational difference after long or short vowels. Word-medial /p/ and /t/ occur quite frequently in the wordlist, always after a short vowel, with mean vowel durations of around 110-125 ms and mean closure durations of around 160-175 ms; medial <gg> is therefore shorter than medial /p/ and /t/, but only by 20-30 ms.

5.6. Analysis and conclusion

5.6.1. Stops

The experimental data in this chapter show that word-initial bare FORTIS stops are approximately 145 ms while word-initial bare LENIS stops are about 95 ms, for a difference of about 50 ms (or just over 50%). In stop + sonorant clusters, FORTIS stops shorten to about 125-

130 ms and LENIS stops to 80-90 ms, for a difference of approximately 40 ms. The difference in closure duration was shown to be statistically significant. The results for VoffT show some differences between LENIS and FORTIS stops, but the differences are not statistically significant. However, the small differences in VoffT may point to some low-level phonetic enhancement, either partial voicing of LENIS stops or active devoicing of FORTIS stops. Differences in VOT were observed for place of articulation, but there is effectively no difference in VOT between LENIS and FORTIS stops. VOT increased a few milliseconds in stop + sonorant clusters, but only a small (negligible) handful of sonorant devoicing cases resulted, and most of these were in /g̊n-/ clusters where VOT increases to 65 ms. In general, the results presented for this dialect of Bernese are in harmony with the results of other experimental studies of Swiss German dialects (Willi 1996, Ham 1998, Kraehenmann 2003) where the primary difference between LENIS and FORTIS stops is closure duration rather than VOT.

There are a few special cases of longer VOT/aspiration in Bernese, viz. the /g̊n-/ and /g̊m-/ clusters and word-final stops discussed above, and recent loanwords from Standard German. The observed increase in VOT specifically in /g̊/ + nasal clusters may be due to a conflict with the tongue dorsum making contact with the velum for /g̊/ followed by the need to lower the velum for the nasal; the presence of 65+ ms of aspiration here may be employed to separate the two segments that use the velum, though there may be additional articulatory factors involved.[74] Recall also that word-final /b̥/ in *näbenab* and /t/ in *nachegfragt* were each followed by about 50 ms of aspiration, and that the /g̊t/ cluster in *nachegfragt* was separated by about 40 ms of aspiration. As for loanwords from Standard German, *packe* ‘to seize’ (also ‘to pack’) was

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[74] Robert Howell (p.c.) notes that /g̊n-/ clusters (and perhaps other /g̊/ + sonorant clusters) are the result of schwa syncope and are thus not original: MHG *genaden* > modern German *Gnaden* ‘graces’. This is likely at least part of the explanation for the behavior of such clusters.

included in the wordlist, as was *picke* ‘to pick’. Other than vowel quality, the two differ only in VOT; the /p/ in *picke* has the expected 16 ms VOT whereas the /p/ in *packe* is followed by 56 ms of aspiration, but closure duration for /p/ differs by only a few milliseconds (140 for *packe*, 146 for *picke*), and both words are also realized with a medial affricate. Therefore, aspiration is present (phonetically, and lexically in some cases) in several different environments in Bernese (and is reported at least for Standard German loanwords in other Swiss German varieties, e.g. Fleischer & Schmid 2006), but it is not used to distinguish LENIS and FORTIS stops.

Finally, although it was not a focus of this study, some remarks can be made regarding word-medial stops. As mentioned in Section 5.5.5, a number of word-medial stops occurred in disyllabic words of the shape CVTV (e.g. *bätte* ‘to pray’, *Chappe* ‘cap’), with closure duration of medial geminate stops ranging from approximately 165-175 ms. These results are similar to the 160-170 ms reported by Kraehenmann (2003:118) for Thurgovian (with 160 ms after long vowels and 170 ms after short vowels), somewhat longer than the 130-160 ms reported for Zürich German (Willi 1996:123), but lower than the 259 ms reported for medial geminate stops in Ham’s (1998:270) study of Bernese (however, some of the speakers in the present study regularly produced closure durations in that range). Furthermore, the comparison of *Schnägge* and *göögge* above shows a difference of less than 10 ms in closure duration following short and long vowels, while vowel duration differs by nearly 90 ms.

These results support a simple two-way distinction (/b̥, p/) for this dialect of Bernese, based solely on duration. Concerning the non-initial three-way distinction (/b̥, p, pː/) for stops proposed for Bernese by Ham, it remains unclear whether the difference is truly contrastive in the dialect he investigates. Seiler (2005b), for example, rejects the three-way distinction for Bernese and adopts instead a two-way singleton/geminate contrast, similar to Kraehenmann's posited contrast for Thurgovian. I argue for a two-way LENIS/FORTIS contrast here, though a closer examination of word-medial and word-final contrasts is needed to solidify this position; this is discussed in more detail below.

5.6.2. Fricatives

The segment /ʋ/ is described by Marti (1985:32) as a semi-vowel that often lacks a strong fricative articulation; I am also unable to find any instances, in the literature or in the present data, where /ʋ/ alternates with /f/ in any environments. It seems reasonable to conclude that /ʋ/ patterns more with the sonorants than the fricatives in Swiss German and that there is therefore no voiced/voiceless contrast for any of the fricatives.

The results for word-initial bare fricatives show that fricative duration varies between about 125 and 135 ms; however, there is no statistically significant difference in duration between /f, s, ʃ, x/. Fricative duration can shorten by around 10 ms in fricative + sonorant clusters. VoffT in fricatives is around 20-25 ms, and any differences are not found to be statistically significant. Sonorant devoicing generally does not occur after fricatives in these results, though just over 25% of /ʃl-/ clusters and just over 50% of /ʃʋ-/ clusters show some sonorant devoicing. However, since sonorant devoicing is mainly limited to these two cluster types, and then only sporadically, it seems safe to say that the fricatives /f, s, ʃ, x/ in this dialect of Bernese are not specified for [spr gl], though the lack of phonetic voicing and sporadic sonorant devoicing suggest that [spr gl] is present phonetically via Vaux's Law. According to Avery & Idsardi (2001:48), unmarked fricatives are enhanced with GW, and the default ‘completion’ gesture for GW is [spr gl]; in Bernese, all fricatives are laryngeally unmarked, and they are also all voiceless, so it appears that Vaux’s Law has, as predicted, supplied all fricatives with a [spr gl] gesture.

Ham (1998:60, 62-64) argues that in Bernese, /v̥/ and /z̥/ are voiceless LENIS fricatives that exhibit a three-way contrast with /f, fː/ and /s, sː/, respectively, while /ʃ/ and /x/ are FORTIS fricatives that exhibit only a two-way durational contrast. However, my results for this dialect of Bernese show no statistically significant difference in fricative duration or VoffT between any of the fricatives, so it is difficult to claim that the specification for /v̥/ and /z̥/ is any different from /ʃ/ and /x/; I argue, therefore, that in this dialect of Bernese, the (singleton) fricatives all share the same specification and that they are either all (voiceless, unmarked) LENIS /v̥, z̥, ʒ̊, ɣ̊/ or all FORTIS /f, s, ʃ, x/; in the discussion that follows, I argue that they are all LENIS.

Additional support for a two-way contrast comes from the examples of medial fricatives in Tables 5.23 and 5.24 above, where both short and long vowels occur before short and long fricatives; there is only an 8 ms difference between short /v̥/ after a long or short vowel, which is less than half the 22 ms difference between long /f/ after a long or short vowel. Again, these results differ from Ham’s results for fricatives (1998:96, 278), where a much greater durational difference is observed between short and long fricatives (“voiceless” and “voiceless geminate” in his terminology) after long vs. short vowels, which in his experiment are equivalent to words of the *Huuffe* and *schaffe* type, respectively. In my results, however, the relatively small difference in fricative duration does not justify a three-way durational contrast for fricatives, but seems to be more a function of the duration of the preceding vowel.

5.6.3. Affricates

The results for the affricates are largely self-explanatory in that there is no LENIS/FORTIS contrast to examine, nor are there any remarkable differences in duration or VoffT to speak of. Some affricate + sonorant clusters, namely /p͜fn-/ and /p͜fr-/, show longer durations, but as mentioned, this may be because these clusters are comparatively rare. In terms of sonorant devoicing, nearly half of /t͜sʋ-/ clusters showed some sonorant devoicing, with /k͜xl-/ clusters a distant second place, and very little in the other affricate + sonorant clusters. These results are similar to the fricatives above where sonorant devoicing occurs sporadically and is mainly limited to one or two cluster types; I argue again here that this bears the hallmark of a phonetic process and that affricates are not specified for [spr gl]. However, since the total duration of initial affricates is 190-195 ms (170-200ms in clusters), which is 50-60+ ms longer than initial stops and fricatives, it is possible that affricates are specified for [spr gl], but the glottal spreading gesture is completed during the articulation of the affricate and thus no sonorant devoicing occurs; it is difficult to test this either acoustically or through phonological processes like sonorant devoicing. Kraehenmann (2003:43-47) posits a [spr gl] specification for affricates in Thurgovian Swiss German, though she explains that it is simply to differentiate stops from affricates, and that the implementation of [spr gl] is frication rather than aspiration. (Recall also that the historical source for affricates is WGmc aspirated stops; see Section 5.2.2. above.)

The question of whether there is a durational contrast for affricates in Bernese remains an open one for now, though the evidence suggests that the difference is allophonic. Kraehenmann (2003:97) does not list a singleton/geminate contrast for the affricates in Thurgovian, and neither do Fleischer & Schmid (2006) for Zürich German. Marti (1985:33-34, 42) similarly does not posit a length contrast for affricates in Bernese. Ham (1998:60, 64-65) posits a durational contrast for Bernese affricates, but then also suggests that they are in complementary distribution, stating that “[s]ingleton affricates derive from word-initial, word-final, and post-consonantal [i.e. sonorant] voiceless aspirated stops in [WGmc]; geminates derive from geminate [intervocalic] voiceless aspirated stops.” Thus it is questionable whether singleton and geminate affricates ever occur in the same environment and could be considered contrastive. It is possible to find minimal or near-minimal pairs in the *Berndeutsches Wörterbuch* such as *chrääze* ‘to carry piggyback’ and *chratze* ‘to scratch’, but this is only an indication of different vowel lengths, not necessarily a difference in affricate duration, and if there is a difference in affricate duration, it may be conditioned by the duration of the preceding vowel. There are a number of word-medial affricates preceded by short vowels in the wordlist, and the durations are as follows:

16) /-p͜f-/ closure: 93 ms; frication: 104 ms; total: 197 ms
/-t͜s-/ closure: 104 ms; frication: 95 ms; total: 199 ms
/-t͜ʃ-/ closure: 119 ms; frication: 83 ms; total: 202 ms
/-k͜x-/ closure: 104 ms; frication: 98 ms; total: 202 ms

These durations are only 5-10 ms longer than word-initial bare affricates, so there does not seem to be the same durational difference between initial singletons and medial geminates as was observed for the stops and fricatives. The only word in the wordlist that could serve as a basis for comparison is the compound word *Trinkgäld* ‘gratuity’ (lit. ‘drink money’), where a non-initial affricate follows a sonorant, so it should be realized as [-ŋk͜x#]. However, in nearly half of the tokens, speakers left out the stop portion of the affricate, so it was realized as [-ŋx#]; in those tokens where the stop portion is retained, it is shortened to around 30 ms. The frication portion of the affricate is relatively constant, whether it is realized with a preceding stop portion or not, averaging around 119 ms. There are therefore differences in affricate duration, but it remains doubtful whether duration is contrastive for affricates in Bernese.

5.6.4. Conclusion

The results of the experiments in this chapter are to a great extent comparable to the results of other studies of Swiss German dialects. There are statistically significant durational differences for both stops and fricatives, and duration remains the most salient distinguishing factor since there are essentially no differences in either voicing or aspiration. The additional experimental results presented above, namely a general lack of sonorant devoicing for all obstruents, support a phonological analysis that the dialect under investigation (and possibly most other Swiss German dialects) is laryngeally unspecified in its obstruent system, relying on durational contrasts rather than laryngeal activity.

From a historical perspective, the realization of the LENIS/FORTIS contrast as a durational contrast can be due to the tendency for voiceless/FORTIS stops to be phonetically longer than voiced/LENIS ones (Ohala 1983, Kingston & Diehl 1994). After the High German Consonant Shift, only the lenis series of stops was left, and as discussed throughout Section 5.2, lenis stops were likely phonetically voiceless, though still lenis. As Romance loanwords were added, the phonetic difference in duration could have gradually been phonologized, and the non-initial durational contrasts already present in Alemannic could have reinforced the durational distinctions in other environments. Thus a phonetic enhancement (longer duration for voiceless stops) has become a phonological contrast. As mentioned in Section 5.1, this is the argument

Page (2001) and others make for Alemannic, and the historical processes outlined in this chapter, as well as the results of the phonetic experiments, support this analysis.

As previously noted, while both Willi (1996) and Kraehenmann (2003) posit a two-way LENIS/FORTIS (or singleton/geminate) contrast for the Zürich and Thurgovian dialects of Swiss German, respectively, and both find that long and short vowels can precede LENIS and FORTIS stops with only minor differences in duration, Ham (1998) finds a more robust three-way surface distinction in a dialect of Bernese and argues for an underlying three-way contrast for the obstruents (arguing specifically for the need for a separate category for geminates) and that vowel length is determined by the following obstruent. In this chapter, my results are more in line with those of Willi and Kraehenmann, particularly for word-medial obstruents, and I argue for a two-way length contrast for the obstruents as well as contrastive vowel length. However, the distribution of vowel length may be more complicated than previously thought. According to the *Berndeutsches Wörterbuch* (von Greyerz & Bietenhard 1997), which often notes durational differences that are not represented orthographically, intervocalic FORTIS singletons (or, at least, single stop graphs) can be preceded by both long and short vowels (I use the dictionary's notation in these examples):

17) *grate* (*aa*) 'to succeed'; but: *chrute* (*ụ*) 'to crash'; *grupe* (*ụ*) 'to cower'

Thus short vowel length is indicated before both single and double stop graphs, medially and finally:

18) *chute* (*ụ*) 'to blow, storm'; *Chutte* (*ù*) 'skirt/jacket'
Hüpe (*ụ̈*) 'rolled waffle'; *Huppi* (*ụ*) 'quiff' (type of hairstyle)
Hut (*ụ*) 'skin'; *hütt* (*ü*) 'today'

It seems based on these orthographic representations that FORTIS singleton and FORTIS geminate stops may not be in complementary distribution and may, in fact, be contrastive, calling for a three-way LENIS/FORTIS/geminate contrast. However, it is unclear in any of these cases whether there is any difference in stop closure duration; the unreliability of (non-standardized) Bernese orthography (and Swiss German orthography in general) has already been noted, as has the substantial regional and inter-/intra-speaker variation in vowel length. Interestingly, although the examples above involve short vowels occurring before single graph stops <t> and <p>, there were, as far as I could tell, no examples of double vowel graphs occurring before double <pp> or double <tt> graphs (e.g. *<aapp>, *<aatt>) in the *Berndeutsches Wörterbuch*, even though double vowel graphs frequently occur before <gg> (= /k/) (as in *göögge* 'to vomit' above) as well as <ff> (as in *Huuffe* 'heap' above) and <ss> (as in *luusse* 'to lurk'); long <ch> (= /xː/) and long <sch> (=/ʃː/) are not represented orthographically (Marti 1985:21; von Greyerz & Bietenhard 1997:8).

Recall also from Section 5.3.4 that in Kraehenmann's (2003:127-128) data, *Tat* 'deed' contains a long vowel and *nett* 'nice' contains a short vowel, and in Schmid's (2004:109) data, *Beet* 'garden bed' contains a long vowel and *Bett* 'bed' contains a short vowel, but vowel length is not reflected orthographically for *Tat* and the orthographic difference between <t> and <tt> is misleading because their results show little or no durational difference between the two. However, Ham's (1998:93) results for word-final stops show much greater differences between FORTIS stops preceded by long vs. short vowels, which leads him to argue for an underlying three-way length contrast in Bernese.

There are a few cases where an increase in stop duration is noted in the *Berndeutsches Wörterbuch*, even though it is not reflected orthographically:

19) *lüte* ‘to ring’ (*ütt*), *luter* (*ụtt*) ‘many, much, exclusively’

Notice also that each of these cases, as well as those in (17) and (18) above, contains a high vowel;[75] Marti (1985:46) mentions that the long high vowels *i*, *u*, and *ü* are shortened before *t* in mono- and polysyllabic words and before *s*, *b*, *d*, *g* in polysyllabic words, but this is not the whole picture. As the examples in (18) illustrate, this shortening also appears to occur for high vowels before *p*; and as the discussion of OSS in Section 5.3.4 illustrates, OSS also affects essentially all vowels – not just high vowels – before LENIS stops, singleton fricatives, and sonorants (examples from Ham 1998:69):

20) **fraːgə* > [frɑg̊ə] ‘to ask’
**xæːz̥ə* > [xæz̥ə] ‘to make cheese’

Seiler (2005b) provides additional examples:

21) MHG [gə'naːdə] > Bernese [g̊nɑːd], [g̊nɑ.də] ‘grace’, ‘graces’
MHG [hoːx] > Bernese [hœːx], [hœ.xər] ‘high’, ‘higher’
MHG [muːl] > Bernese [muːl], [mʏ.lər] ‘mouth’, ‘mouths’

There could therefore be two separate processes at work here: high vowel shortening before /p/ and /t/, and OSS before LENIS obstruents and sonorants. In the case of OSS, the fact that singleton fricatives pattern with LENIS stops and sonorants in this process supports the view that singleton fricatives can be analyzed as LENIS /v̥, z̥, ʒ̊, ɣ̊/, which is the view other researchers have taken (e.g. Willi 1996, Fleischer & Schmid 2006).

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[75] There is also potentially at least one case with a non-high vowel: *schrote* ‘to chop coarsely’.

While I feel that further investigation of the relationship between vowel quantity and the LENIS/FORTIS contrast in Bernese is called for, the phonetic evidence (lack of voicing and aspiration; clear durational differences) and phonological evidence (vowel length distribution; MSL and OSS) examined so far supports a two-way LENIS/FORTIS contrast based on length for Bernese stops /b̥, d̥, g̊/~/p, t, k/ and fricatives /v̥, z̥, ʒ̊, ɣ̊/~/f, s, ʃ, x/; length does not appear to be contrastive for affricates /p͜f, t͜s, t͜ʃ, k͜x/. This analysis accounts for OSS and the distribution of vowel length straightforwardly: OSS affects vowels followed by LENIS obstruents (/CV:DV/ → [CVDV]), but since OSS applies on a lexeme-by-lexeme basis (Seiler 2005b), LENIS obstruents can be preceded by both long and short vowels; additionally, rather than analyzing words such as *Schnägge*, *schaffe* and *göögge*, *Huuffe* (Section 5.5.5) as underlyingly /CVT:V/ and /CV:TV/, respectively, they can simply be analyzed as /CVTV/ and /CV:TV/. Furthermore, the evidence suggests that orthographic <pp> and <tt> represent /p/ and /t/, respectively, when preceded by a short vowel. This phonological analysis is supported by my own phonetic results, as well as those of Kraehenmann (2003) and Willi (1996) and others, which show more or less uniform obstruent duration regardless of preceding vowel duration.

These observations also support an analysis of contrastive vowel length wherein long and short vowels can precede LENIS and FORTIS stops, which means that length is then contrastive for both vowels and consonants (except affricates; Ham 1998 and Kraehenmann 2003 also find a durational contrast for /l/ and nasals), providing a unified, system-wide contrast based on phonological length. This would explain why, in Ham's Bernese analysis, long vowels only occur in [CV:TV] words while short vowels only occur in [CVT:V] words; the difference in closure duration is not contrastive, but phonetic, conditioned by the length of the preceding vowel. Furthermore, as mentioned in Section 5.3.4, Page (2001), Kraehenmann (2003), and Seiler (2005a, b) all propose that in Alemannic, both vowel and consonant length are contrastive, and that long vowels are bimoraic (μμ), short vowels and geminate consonants are monomoraic (μ), and singleton consonants are weightless (see also Hayes 1989).

Recall also that Seiler (2005b) argues for a privative analysis of vowel length in Bernese, where long vowels are specified for length but short vowels are unspecified; there is some evidence that this analysis can be extended to the obstruents as well, with FORTIS obstruents underlyingly moraic, and unspecified LENIS obstruents underlyingly weightless. The results in Section 5.5.4, where intervocalic /g̊/ is 60 ms but increases to 83 ms in /g̊t/ clusters, suggest that some assimilation is taking place, indicating that LENIS obstruents are unspecified for length. In MSL, /CVD/ words lengthen to [CVːD] to meet a minimal bimoraic word requirement; in this case, both the vowel and the LENIS obstruent are unspecified for length, but because the vowel is moraic by default, it lengthens, rather than the LENIS obstruent (*[CVDː]). MSL does not apply in /CVT/ words because the FORTIS obstruent is underlyingly moraic, thus the bimoraic minimum is already met. A moraic analysis for FORTIS obstruents also explains the high vowel shortening before /p/ and /t/ in Bernese cited by Marti (1985:46) and described above (MHG *lût* > Bernese *lut* 'loud'), where a highly marked superheavy syllable (CVːT = μμμ) becomes an unmarked heavy syllable (CVT = μμ); the fact that only high vowels seem to be affected can be explained by a cross-linguistic tendency for high vowels to be phonetically shorter than low vowels (see Page 2001 and references therein). Thus /CVT/ words contrast with /CVːT/ words at the surface level ([CVT]~[CVːT]) whereas /CVD/ words never surface; only [CVːD] is allowed to surface. As Seiler (2005b) explains, MSL feeds directly into OSS; because only [CVːD] appears at the surface, morphological paradigms are affected because MSL allows for the reanalysis of stems as having an underlying short vowel, thus MHG /huːs/, /hyː.sər/ ‘house’, ‘houses’ is reanalyzed in Bernese as /huz̥/ → [huːz̥] (MSL), [hʏ.z̥ər] (OSS). The phonetic and phonological evidence presented in this chapter illustrate that both vowel length and consonant length are contrastive, and that short segments are unspecified for length, supporting a privative analysis of phonological length.

In terms of a contrastive hierarchy, some refinement of the contrast and enhancement model may be needed. Kraehenmann (2003) argues for a structural as opposed to a featural analysis of length in Thurgovian Swiss German, with contrastively long segments represented as a single root node occupying two timing slots in the skeletal tier, adding that moraicity is licensed by syllabification in the rhyme (nucleus and/or coda) of the syllable; thus “[l]ength and weight can be represented independently: Segment length does not always go hand in hand with moraic status in Thurgovian” (2003:28). This allows for an analysis of word-initial FORTIS stops as contrastively long but not necessarily weight bearing (e.g. in word-initial onset position); this analysis works equally well for the Bernese data presented in this chapter. The diachronic account of the durational contrast in Bernese and other modern Swiss German dialects therefore points to the transphonologization of a laryngeal (featural) contrast into a structural length contrast; this is reminiscent of the account of tonogenesis presented in Hombert et al. (1979), where historical obstruent laryngeal contrasts were transphonologized into tonal contrasts carried on vowels via the phonetic effect of different laryngeal specifications on the F_0 of adjacent vowels. However, it remains to be determined whether there is any difference in the way structural contrast would interact with featural contrast in a contrastive hierarchy; the SDA described in Section 2.11 only refers to features. In principle, it seems that the contrast and enhancement model ought to be able to accommodate non-featural phonological contrasts, but this aspect of the model has not been developed or made explicit.

Chapter 6: Conclusion

6.1. Summary

Languages differ both in what phonological features are used in contrasts and in the way underlying phonological contrasts are phonetically implemented. The role of phonology is to differentiate one phoneme from another, and languages can differ in both phoneme inventory and how (i.e. by which features) those phonemes are differentiated, but language-specific variation in the implementation of the same phonological contrast is the role of phonetics. This dissertation has investigated how phonology is mapped to phonetics, as well as the nature of phonological contrast and how it is phonetically enhanced. I have shown that application of the 'contrast and enhancement' model (Hall 2011) can shed light on both the organization and specification of phonological features as well as the phonetic implementation and enhancement of those features. The relationship between phonetics and phonology, specifically the phonetic implementation and enhancement of phonological contrast, was investigated for the LENIS/FORTIS contrast in dialects of three Germanic languages that were reported to have different laryngeal settings. In Section 1.3, I summarized a number of studies on the LENIS/FORTIS contrast in various Germanic dialects, and many of these studies provided acoustic or articulatory data showing that it is not unusual to have both active voicing and active glottal spreading gestures in the same language. However, the presence of phonetic voicing does not necessarily imply a phonological [voice] specification, nor does the presence of a phonetic glottal spreading gesture necessarily imply a phonological [spr gl] specification. As I have argued throughout this dissertation, phonological activity determines which feature is contrastive; if two contrasting segments each have active gestures at the phonetic level, and only one is needed to maintain the contrast, then one gesture is predicted to be redundant while the other is predicted to be phonologically contrastive, and that feature tends to trigger or be targeted by phonological processes. This slightly revised version of the ‘contrast and enhancement’ model therefore includes, and relies on, privativity (at least for some features) and ‘laryngeal realism’. The experimental phonetic results presented in this dissertation support the model, with clear phonetic differences between LENIS and FORTIS obstruents, but also with clear differences in phonological behavior (with the possible exception of Dutch).

In Chapter 3, I found that in Norwegian, LENIS obstruents could be produced with considerable voicing, FORTIS stops were produced with aspiration, all FORTIS obstruents could be produced with preaspiration, and all FORTIS obstruents triggered both sonorant devoicing and regressive devoicing of adjacent LENIS obstruents. Although phonetic voicing was present in word-initial LENIS obstruents, there was no evidence of any phonological activity, suggesting that voicing in LENIS obstruents is redundant. Based on these phonetic results, I argued that all FORTIS obstruents were specified for [spr gl] while all LENIS obstruents are laryngeally unspecified.

In Chapter 4, the phonetic and phonological results for Dutch were inconclusive; all phonetic measurements were shown to be statistically significant, indicating a clear LENIS/FORTIS distinction, but suggesting that phonetic gestures other than voicing are employed to differentiate LENIS from FORTIS obstruents. Additionally, any evidence of Regressive Voicing Assimilation (RVA) was sparse at best, which indicates a much lower level of phonological activity for [voice] than was anticipated. This is a challenge for the model proposed here, with multiple features serving to make a distinction, none of which is unambiguously phonologically active; however, as noted, van Alphen & Smits (2004) and Pinget (2015) suggest that change may be underway in Dutch. If this is the case, then the decrease in phonetic voicing may be triggering an increase in other gestures in order to maintain the contrast, which could lead to the reanalysis of a different feature as contrastive; this still fits the model, but the organization and implementation of features in Dutch appears to be in flux.

Finally, in Chapter 5, duration was the only phonetic measurement that proved to be statistically significant for the LENIS/FORTIS distinction in Swiss German; the slightly longer voicing duration in LENIS stops can easily be understood as a phonetic enhancement. There was some evidence of phonological length spreading in obstruent clusters, but the more telling phonological evidence comes from vowel length alternations: short vowels (underspecified for length) lengthen before non-weight bearing LENIS obstruents in monosyllables, but underlyingly long FORTIS obstruents do not trigger vowel lengthening, and may in fact trigger vowel shortening in some cases. Based on these results, I argued that all Bernese obstruents are laryngeally unspecified, that the contrast is based on phonological length, and that contrastive length is moraic (depending on the position in the syllable, following Kraehenmann 2003). The fact that LENIS obstruents do not contribute weight, and can potentially become lengthened in some environments, suggests that they are unspecified for length.

Additionally, the diachronic background presented in several chapters has highlighted the role of sound change in shaping phonological contrast, and how, in some cases, phonetic enhancement can become phonological contrast. In Section 1.2 I showed that in Proto-Indo-European, there was a three-way laryngeal contrast between voiceless, voiced, and voiced aspirated stops; in PGmc, this became a two-way laryngeal contrast in addition to a stop/fricative contrast via Grimm's Law, followed by a two-way laryngeal contrast for the fricatives as well via Verner's Law and spirantization. It was further argued, following Iverson & Salmons (2003a), that this was the introduction of [spr gl] as a phonologically contrastive feature in Germanic; presumably, [spr gl] had been present as a phonetic enhancement prior to this but subsequently became phonologized.

In Norwegian, the inherited two-way contrast persists to the present day, with contrastive [spr gl], but the only possible laryngeal contrast for the fricatives is between /f/ and /ʋ/ since PGmc *þ and *ð became stops, *h was either lost or retained as /h/, and *z became rhotacized, leaving /s/ without a LENIS counterpart; nevertheless, the results from Chapter 3 indicate that /s/ appears to have retained its [spr gl] specification.

The inherited two-way contrast also persists in Dutch stops (with the exception of the lenis velar stop, which became a fricative), though the contrast apparently became based on [voice] rather than [spr gl], possibly due to Romance influence (Iverson & Salmons 2003b). The two-way contrast in Dutch fricatives seems to have arisen due to many lexemes undergoing spirant lenition while others did not, and possibly also from loanwords; thus the two-way fricative contrast is perhaps only partially inherited, but otherwise innovated. However, as mentioned several times, Dutch LENIS fricatives are increasingly produced without phonetic voicing. If [spr gl] is present at the phonetic level in Dutch FORTIS fricatives via Vaux's Law, then there exists the possibility that [spr gl] could eventually be reanalyzed as phonologically contrastive, which could then spread through the rest of the obstruent system; this echoes the argument made by Iverson & Salmons (2003a), where contrastive [spr gl] entered the PGmc system via the fricatives.[76]

It seems that in Swiss German and other Upper German dialects, the effects of the High German Consonant Shift removed the inherited two-way laryngeal contrast, as lenis stops no longer contrasted directly with FORTIS stops, which had become affricates or fricatives. The innovated two-way length contrast in Swiss German appears to have several possible sources, including Romance loanwords and native morphological patterns; in any case, there is no evidence of a laryngeal contrast anywhere in the Swiss German obstruent system. One common thread through all of this is that the presence of [spr gl], whether phonetic or phonological, has been – and possibly continues to be – a driving force of sound change in Germanic.

We have so far examined and discussed the experimental results for each language in isolation, but one of the main issues this dissertation addresses is language-specific variation, which entails the comparison of one language to another. The following sections compare key results for the three languages side by side, leading to further analysis and discussion. The focus here is on the variation of phonetic implementation of the underlying LENIS/FORTIS contrast, which I have argued is largely laryngeal in Norwegian and Dutch, but durational in Swiss German. These results will also be placed in the broader synchronic context of modern Germanic outlined Section 1.3.

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[76] Robert Howell (p.c.) notes again that Randstad Dutch has been in flux for possibly as long as four centuries while southern Dutch has been more stable, perhaps due in part to a more stable demographic history in the southern Dutch area compared to large numbers of Franconian-speaking immigrants in the northern Dutch area from the Early Modern period to the present.

6.1.1. Stops

This section compares the results for closure duration, voicing duration during closure (VoffT), VOT, and VOT in FORTIS stop + sonorant clusters that were presented in Chapters 3, 4, and 5, followed by a discussion and summary of the comparison.

6.1.1.1. Closure duration

	Norwegian		Dutch		Swiss German	
	mean	s.d.	mean	s.d.	mean	s.d.
/b-/	126.93	28.00	108.97	23.36	96.01	37.42
/p-/	119.88	29.27	123.74	24.62	142.78	41.75
/d-/	118.22	26.83	92.33	23.19	91.70	47.10
/t-/	115.34	27.57	109.13	19.42	145.49	44.58
/g-/	115.43	23.41			94.56	47.76
/k-/	108.71	24.03	100.32	24.20		

Table 6.1 Comparison of stop closure duration in ms

In Table 6.1, Norwegian LENIS stops are slightly longer than FORTIS; this difference was not found to be statistically significant (Section 3.5.1.1). Interestingly, Norwegian LENIS stops are also consistently longer than LENIS stops in the other languages, and are as long as or longer than Dutch FORTIS stops. However, LENIS stops are shorter than FORTIS in both Dutch and Swiss German, and the differences are statistically significant in both languages (Sections 4.5.1.1 and 5.5.1.1, respectively). Furthermore, we see here a difference between LENIS and FORTIS stop closure duration of approximately 15 ms in Dutch compared to about 50 ms in Swiss German.

6.1.1.2. VoffT

	Norwegian		Dutch		Swiss German	
LENIS	mean	s.d.	mean	s.d.	mean	s.d.
/b-/	83.43	22.20	66.38	35.21	41.92	25.32
/d-/	86.75	24.00	52.86	29.61	40.75	17.99
/g-/	68.44	25.08			44.60	22.55
pooled	79.54	23.76	59.62	32.97	42.38	21.91
FORTIS	mean	s.d.	mean	s.d.	mean	s.d.
/p-/	30.78	11.49	23.88	21.29	39.25	19.85
/t-/	29.92	11.85	16.82	13.43	36.47	14.99
/k-/	27.14	12.71	14.20	11.82		
pooled	29.28	12.01	18.40	16.48	37.67	17.66

Table 6.2 Comparison of VoffT in ms

Table 6.2 shows a decrease in voicing during closure from Norwegian to Dutch to Swiss German. The comparison of Norwegian to Dutch is particularly interesting, and even though Dutch LENIS stops are shorter than Norwegian LENIS stops, the % glottal pulsing is still greater in Norwegian (68.69%; Section 3.5.1.3) than in Dutch (62.60%; Section 4.5.1.3). Thus Norwegian, a [spr gl] language, appears to employ phonetic voicing in LENIS stops to a greater extent than Dutch does.

6.1.1.3. VOT

	Norwegian		Dutch		Swiss German	
LENIS	mean	s.d.	mean	s.d.	mean	s.d.
/b-/	13.22	5.41	14.44	5.18	15.26	6.75
/d-/	26.60	10.61	21.41	6.42	20.82	8.94
/g-/	27.33	5.89			(28.24)	(9.69)
pooled	22.38	7.30	17.93	6.77	18.09	8.36
FORTIS	mean	s.d.	mean	s.d.	mean	s.d.
/p-/	56.11	16.78	17.45	5.80	16.63	3.90
/t-/	62.28	15.11	29.70	9.97	18.71	5.06
/k-/	70.45	11.92	(39.49)	(11.12)		
pooled	62.95	14.60	23.48	10.15	18.00	4.76

Table 6.3 Comparison of VOT in ms

The comparison of VOT in Table 6.3 shows that the main difference for the LENIS stops is a slightly longer VOT for /d/ in Norwegian, but the languages are otherwise quite similar; the obvious difference in the FORTIS stops is that VOT is much greater in Norwegian. The velars were excluded from the pooled results for Dutch and Swiss German to show that there is essentially no difference between Dutch and Swiss German LENIS stops on the one hand and between Swiss German LENIS and FORTIS stops on the other; the difference in VOT between Dutch LENIS and FORTIS stops, however, is shown to be statistically significant (Section 4.5.1.4).

6.1.1.4. VOT in FORTIS stop + sonorant clusters

	Norwegian		Dutch		Swiss German	
cluster	mean	s.d.	mean	s.d.	mean	s.d.
/pj-/	72.31	16.89				
/pl-/	59.12	18.97	28.77	12.45	19.00	6.89
/pr-/	55.65	23.99	36.20	17.56	16.44	6.77
/tr-/	72.12	21.39	53.61	16.87	26.28	7.54
/tʋ-/	93.56	22.41	96.85	23.81		
/kl-/	80.14	23.01	62.51	14.29		
/kn-/	83.24	12.04	64.75	20.18		
/kr-/	72.88	21.84	60.78	17.66		
/kʋ-/	75.28	14.46	79.42	18.83		

Table 6.4 Comparison of VOT in FORTIS stop + sonorant clusters

While Chapters 3, 4, and 5 all have sections focusing on sonorant devoicing *per se*, various factors (e.g. schwa epenthesis) affect sonorant devoicing. Rather than directly compare sonorant devoicing across languages, VOT in FORTIS stop + sonorant clusters is compared in Table 6.4, and this reflects the degree to which sonorant devoicing takes places in each language more generally. As noted in Section 5.5.1.5, sonorant devoicing is almost non-existent in Swiss German. What is interesting is the large increase in VOT in Dutch clusters compared to bare stops in Table 6.3; while it is still generally lower than Norwegian, VOT is essentially identical in /tʋ-/ and /kʋ-/ clusters in both languages. As far as I am aware, only Simon has noted a similar VOT increase in clusters in Dutch (2010:80); it is unclear why there is such a large difference between bare stops and stop + sonorant clusters in Dutch, or why /tʋ-/ and /kʋ-/ clusters in particular would show such large increases in VOT.

6.1.1.5. General comparison of stops

In Norwegian, differences in closure duration are not statistically significant for the LENIS/FORTIS contrast in stops, but differences in VoffT, % glottal pulsing, and VOT are (Sections 3.5.1.1-4). In Dutch, closure duration, VoffT, % glottal pulsing, and VOT are all statistically significant (Sections 4.5.1.1-4). In Swiss German, only closure duration is statistically significant (Sections 5.5.1.1-3). These observations, combined with the results in Tables 6.1-4 above, illustrate how the LENIS/FORTIS contrast is phonetically expressed in each language: Norwegian appears to rely on aspiration and voicing, but not duration; Dutch apparently relies on a combination of factors, including at least duration and voicing, but possibly also (increasingly?) aspiration; and Swiss German relies solely on duration.

6.1.2. Fricatives

This section compares the results for fricative duration and fricative voicing duration (VoffT) that were presented in Chapters 3, 4, and 5, with some discussion of fricative sonorant devoicing.

Fricative duration is compared in Table 6.5. Norwegian exhibits a clear durational difference between the three fricatives measured here, though only /f-/ and /ʋ-/ are arguably laryngeally contrastive. The durational differences between the Dutch fricative pairs /v/~/f/ and /z/~/s/ are found to be statistically significant (Section 4.5.2.1) but there is no statistically significant difference between the Swiss German fricatives (/ʋ/ excluded) (Section 5.5.2.1).

6.1.2.1. Fricative duration

	Norwegian		Dutch		Swiss German	
	mean	s.d.	mean	s.d.	mean	s.d.
/ʋ-/	83.69	21.31	91.56	25.03	88.20	29.24
/v-/ /v̥-/			124.33	18.65	136.26	35.48
/f-/	136.95	24.38	147.26	22.86		
/z-/ /z̥-/			123.18	26.05	125.11	24.27
/s-/	160.60	28.33	161.95	22.20		
/ʒ̊-/					131.84	30.78
/x-/ /ɣ̊-/			142.93	29.61	137.63	36.64

Table 6.5 Comparison of fricative duration in ms

6.1.2.2. VoffT

	Norwegian		Dutch		Swiss German	
	mean	s.d.	mean	s.d.	mean	s.d.
/ʋ-/	71.96	19.87	84.63	26.31	88.20	29.24
/v-/ /v̥-/			18.64	15.33	26.93	15.37
/f-/	22.37	10.82	11.82	9.52		
/z-/ /z̥-/			50.07	41.59	23.50	11.60
/s-/	12.05	8.14	12.52	5.75		
/ʒ̊-/					20.74	15.53
/x-/ /ɣ̊-/			16.76	10.32	23.66	14.97

Table 6.6 Comparison of fricative VoffT in ms

Table 6.6 compares fricative voicing duration. Notice that /ʋ/ has both a similar duration in Table 6.5 and is similarly voiced in all three languages. Additionally, Dutch /v/ and /z/ are each about 124 ms in duration, but /z/ shows more than twice as much voicing as /v/ does (but also a larger standard deviation, indicating more variation). Notice also that while Norwegian /f/ and Swiss German /v̥/ have nearly the same durations (ca. 136 ms) and VoffT durations (ca. 22/27 ms), Norwegian /f/ frequently devoices a following sonorant (Section 3.5.2.5) but Swiss German /v̥/ almost never does (Section 5.5.2.4); thus even though they are phonetically quite similar, they differ in their phonological specifications. Along the same lines, Norwegian /s/ and Dutch /s/ are each 160 ms in duration with 12 ms of voicing, but Norwegian [ʂɭ-] clusters show 33.47 ms sonorant devoicing (Section 3.5.2.5) while Dutch /sl-/ clusters show only 20.45 ms sonorant devoicing, with 1/3 of the Dutch tokens showing no sonorant devoicing at all (Section 4.5.2.5). This indicates that there is a glottal spreading gesture in Dutch FORTIS fricatives, but the phonetic variation in sonorant devoicing suggests that Dutch /s/ is not specified for [spr gl], while the relative stability of sonorant devoicing in Norwegian indicates that /s/ is specified for [spr gl].

6.1.3. General discussion

In addition to the single-language evidence provided in Chapters 3-5, comparative evidence illustrates the degree of phonetic and phonological variation in the realization of the LENIS/FORTIS contrast. The framework adopted in this dissertation, which consists of privativity (Section 2.6), 'laryngeal realism' (Section 2.7), and the 'contrast and enhancement' model (Sections 2.10-11), is able to account for this variation. Laryngeal realism specifies that either [spr gl] or [voice] is contrastive in a two-way system, but not both; privativity posits that a segment is either specified or unspecified for that feature; and contrast and enhancement provides a model for determining which features are contrastive, how they relate to one another, and which redundant features can be used to enhance contrastive ones.

In Norwegian, the contrast is realized strictly in terms of laryngeal activity: FORTIS obstruents are specified for [spr gl], LENIS obstruents are laryngeally unspecified, and there is no statistically significant difference in duration (Section 3.5.1.1); voicing in LENIS stops phonetically enhances the laryngeal contrast (Section 3.6). Additional support for a [spr gl] specification of all FORTIS obstruents is the presence of preaspiration (Section 3.5.4). Based on phonological activity such as sonorant devoicing and assimilation, the Norwegian FORTIS fricatives pattern with the FORTIS stops and therefore share the same [spr gl] specification, indicating that [spr gl] is contrastive for all obstruents, ordered below [sonorant] but above [continuant] (Section 3.6.3). The phonetic similarity of certain Norwegian segments to segments in other languages does not necessarily entail phonological similarity, as the comparison of Norwegian /f/ to Swiss German /v̥/ and Norwegian /s/ to Dutch /s/ illustrates.

The Dutch data suggest that the contrast in Dutch is realized with a combination of laryngeal activity and duration; as noted above, closure duration, VoffT, % glottal pulsing, and VOT are all statistically significant in Dutch (Sections 4.5.1.1-4). In terms of phonological activity, there is little evidence of RVA, but instead a pattern of voicelessness in obstruent-obstruent clusters (Section 4.5.3) and sporadic sonorant devoicing in obstruent-sonorant clusters (Sections 4.5.1.6, 4.5.2.5); in other words, it appears that consonant clusters share a glottal spreading gesture at least some of the time. This is in harmony with Pinget’s (2015) observations, noted previously, that a sound change in the direction of devoicing is underway in Dutch, and it is more advanced for the LENIS fricatives than for the LENIS stops. If we assume that [voice] was, or still is, contrastive, then it appears as though phonetic voicing is becoming less prominent in LENIS obstruents while the glottal spreading gesture is becoming more prominent; this could lead to a reanalysis of [spr gl] as contrastive rather than enhancing.

The contrast in Swiss German is based on duration rather than any laryngeal activity, since only duration, but not voicing or VOT, is shown to be statistically significant, and sonorant devoicing is essentially absent for all obstruents (Sections 5.5.1-2). Since duration is the primary cue to the phonological distinction, it makes sense that the durational difference is much greater in Swiss German than in Dutch at the phonetic level; duration is only one of several cues in Dutch. Contrastive length appears to have developed from the removal of contrastive aspiration as a result of the High German Consonant Shift, where WGmc aspirated stops became fricatives or affricates; existing non-initial length distinctions and loanwords with voiceless, unaspirated stops may have played a role in creating the contrast (Sections 5.2.2-6), which began as a phonetic difference in duration (as in Dutch) and became a phonological contrast (Section 5.3.4). Phonological processes such as monosyllabic lengthening (MSL) and open syllable shortening (OSS) reveal that FORTIS stops pattern with FORTIS fricatives in being contrastively long/weight bearing while LENIS stops and fricatives pattern together in being unspecified for length, or contrastively weightless (Sections 5.3.4, 5.5.5).

1)

PGmc
fortis lenis
[spr gl] [ ]

	Norwegian		Dutch		Swiss German	
	FORTIS	LENIS	FORTIS	LENIS	FORTIS	LENIS
Contrast:	[spr gl]	[ ]	[ ]	[voice]	long	[ ]
Enhancement:		[voice]	[spr gl]		length (historically)	

The historical development of the PGmc fortis and lenis obstruent specifications, with the resulting contrastive specifications and phonetic enhancements in the modern languages examined in this dissertation, is portrayed in (1). Based on historical evidence such as Grimm's Law (Section 1.2), we can assume a contrastive [spr gl] specification for PGmc fortis obstruents. This contrast has continued into modern Norwegian, where the laryngeally unspecified LENIS obstruents are phonetically enhanced with [voice]. In modern Dutch, to the extent to which it can be determined, [voice] is contrastive for the LENIS obstruents while the FORTIS obstruents are enhanced with [spr gl]. In Swiss German, FORTIS obstruents are contrastively long, which is partially (historically) the result of a phonetic enhancement of length. This illustrates that languages deriving from the same (but likely not homogeneous) parent language can develop drastically different phonological systems.

6.2. Limitations

The main focus of this dissertation has of course been word-initial LENIS/FORTIS contrasts, but the contrast is manifested in different ways in different word positions. The word-initial focus also conflicts somewhat with another aim of this study, which is to determine which features are contrastive. As discussed in Section 2.11, one diagnostic for contrastivity is phonetic variability:

enhancement is variable while distinctive features are categorical; but another diagnostic is phonological activity, where only contrastive features participate in phonological processes. Sonorant devoicing and assimilation are phonological processes, but (word-internal) assimilation environments were of secondary importance in the design of the experiments in Chapters 3, 4, and 5. However, both Norwegian (Kristoffersen 2000:116-120) and Swiss German (Chapter 5) have quantity contrasts, and Dutch has a vowel length contrast (Booij 1995:13-16), and taking these additional factors into consideration to design a more assimilation-oriented experiment would have added unmanageable layers of complexity to the experimental design for this dissertation.

Additionally, as demonstrated in Section 1.3 as well as in the experimental chapters, there is a tremendous amount of variation in the realization of the LENIS/FORTIS contrast across Germanic – between languages, dialects, and even speakers. It would, of course, be impossible to cover any aspect of the LENIS/FORTIS contrast over such a wide geographical area. This dissertation presents a novel comparison between three languages with different laryngeal systems, and covers only western Oslo Norwegian, Randstad Dutch, and Bernese Swiss German.

Finally, there are also some methodological limitations. While a sociophonetic approach may have resulted in more natural speech due to a more comfortable and familiar setting for the speakers, it also resulted in a slightly noisier signal than if the speakers had been recorded in a soundproof booth. There is also a focus on production, even though the value of perception studies cannot be understated. Another methodological limitation is the design of the experiment, with each target word embedded in a carrier phrase in postvocalic position, as opposed to utterance-initial, post-obstruent, or in isolation; again, the focus was on word-initial obstruents – both stops and fricatives (and affricates) – as well as obstruent-sonorant clusters, and examination of all these combinations in multiple environments would have been untenable and likely also burdensome for the speakers who volunteered to participate. Limitations can sometimes be a good thing, and there is always the possibility for future research to fill in any of these gaps.

6.3. Looking forward

Based on analysis of the results of the experiments included in this dissertation, assimilation in both Norwegian and Dutch as well as the role vowel quantity and vowel length variation in Bernese would benefit from further research. While there are several experimental studies on assimilation in Dutch (cited in Section 4.3.2), I am not aware of any in Norwegian. Several of the studies cited in Chapter 5 examine vowel length in Swiss German dialects, but vowel quantity seems to exhibit a great deal of regional variation. Given such variation, not just in Bernese but across Germanic, there is clearly also a need for additional experimental studies to gain a better understanding of the phonetic variation on phonological contrast in general.

The diachronic aspect also holds promise for future research. I have described some of the posited sound changes as possible reanalyses of phonetic enhancements as phonological contrasts and vice versa (e.g. the length contrast in Swiss German), but Oxford (2015) applies the contrastive hierarchy to diachronic changes in the Algonquian vowel system, adding principles to predict the types of possible changes that could occur in a given hierarchy, and positing a reordering of contrastive features over time. Relevant here is the notion that as contrastive features are reranked over time, they tend to do so one step at a time, and in the same direction – either promoted up the hierarchy or demoted down the hierarchy. Applying this to Germanic, it seems that [spr gl] may have started out in the hierarchy below [voice] in PIE, with [voice] contrastive for all stops and [spr gl] only contrastive for the voiced aspirates; Grimm's Law indicates that [spr gl] got promoted above [voice], and after Verner's Law, [spr gl] seems to have been promoted above [continuant], since both stops and fricatives developed a laryngeal contrast; modern Icelandic is the extreme case, with [spr gl] promoted above [sonorant] since sonorants exhibit a voicing contrast (Section 1.3.1). Although Oxford does not explicitly include phonetic enhancement in his framework, he does posit a ‘segmental reanalysis hypothesis’ (2015:317) that accounts for the phonologization of a phonetic change; this could provide the mechanism to explain the sound change that appears to be underway in modern Dutch, where contrastively unspecified FORTIS obstruents could be reanalyzed as contrastively [spr gl].

6.4. Conclusion

The focus of this dissertation has been the phonetic and phonological analysis of the LENIS/FORTIS contrast in three related languages – Norwegian, Dutch, and Swiss German – that differ from each other in the phonological specification underlying the LENIS/FORTIS contrast. I have argued for privativity and laryngeal realism, such that either LENIS or FORTIS obstruents are specified, but not both, and I have argued that the contrast can be phonetically enhanced, based on Hall’s (2011) model of contrast and enhancement.

I have also addressed several problems. In Chapter 3, I provided evidence that Norwegian FORTIS stops and FORTIS fricatives behave the same with regard to phonological processes such as sonorant devoicing and assimilation and they are contrastively specified for [spr gl] while the LENIS obstruents are laryngeally unspecified; the fact that /s/ lacks a voiced counterpart /z/ does not mean that it also lacks a laryngeal specification. I also showed that both FORTIS stops and FORTIS fricatives can be realized with preaspiration, which is additional evidence of a [spr gl] specification for all FORTIS obstruents. The results for Dutch in Chapter 4 are similar to previous studies, but they also support recent studies (van Alphen & Smits 2004, Pinget 2015) that suggest sound change is underway; voicing is often weak, and there is a general lack of the expected pattern of voicing assimilation. While the Dutch results generally support a LENIS/FORTIS contrast, it is unclear if [voice] remains contrastive, and if it is, it appears that phonetic voicing is only one of several cues. Chapter 5 presented the results for Swiss German, which I analyze as a laryngeally unspecified language in every way; the LENIS/FORTIS contrast is based instead on phonological length, with FORTIS obstruents contrastively long while LENIS obstruents are unspecified for length. This analysis is supported by monosyllabic lengthening (MSL), which lengthens vowels before LENIS obstruents in monosyllabic words, indicating that underlyingly long FORTIS obstruents can contribute to syllable weight while unspecified LENIS obstruents do not.

This dissertation contributes to Germanic laryngeal typology as well as laryngeal phonetics and phonology more broadly by analyzing raw phonetic data from three Germanic languages and applying the results to a framework that was designed to account for both phonetic variation and phonological contrast. The results and analysis presented here fill in some gaps but also raise new questions, and this can lead to a deeper understanding of the separate but related roles of phonetics and phonology.

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Appendix A: Norwegian wordlist

Target Words:

bakke ‘hill’

bjørker ‘birches’

bjørner ‘bears’

bløffe ‘to bluff’

blotte ‘to expose’

bratte ‘steep slope’

brekke ‘to break’

bytte ‘to exchange’

drikke ‘to drink’

droppe ‘to drop’

dukke ‘to dive’

dvele ‘to linger’

dverger ‘dwarves’

dyktig ‘diligent’

fattig ‘poor’

fiske ‘to fish’

fjetre ‘to bewitch’

fjotter ‘simpletons’

flaske ‘bottle’

flytte ‘to move’

fnise ‘to giggle’

fnyse ‘to snort’

frakker ‘jackets’

frykte ‘to fear’

gasse ‘to gas’

gjette ‘to guess’

glatte ‘to smooth’

glippe ‘to loosen’

gnafse ‘to munch’

gnistre ‘to sparkle’

godter ‘candy’

grøfter ‘ditches’

gruppe ‘group’

jakte ‘to hunt’

kaste ‘to throw’

klasse ‘class’

klikke ‘to click’

knapper ‘buttons’

knekke ‘to snap’

kraftig ‘powerful’

krysse ‘to cross’

kutte ‘to cut’

kvasse ‘sharp’ (infl.)

kvikke ‘to cheer up’

lappe ‘to repair’

lette ‘to ease’

masse ‘mass’

miste ‘to lose’

nakke ‘neck’

nytte ‘to use’

pakke ‘package’

pjatte ‘to blather’

pjuske ‘to blow’

plaske ‘to splash’

pliktig ‘obligatory’

presse ‘to press’

proppe ‘to stuff’

puste ‘to pant’

raste ‘to rest’

redsel ‘fear’

riktig ‘correct’

saftig ‘juicy’

sitte ‘to sit’

slappe ‘to relax’

slutte ‘to end’

smatte ‘to smack one’s lips’

smitte ‘to infect’

snakke ‘to talk’

snitte ‘to carve’

svekke ‘to impair’

svikte ‘to disappoint’

takke ‘to thank’

teppe ‘carpet’

trakte ‘to aspire’

trykke ‘to press’

tverre ‘sideways’

tvile ‘to doubt’

vaske ‘to wash’

viktig ‘important’

vrake ‘to refuse’

vrikke ‘to twist’

Distractors:

allslags ‘of all kinds’
anleggsplan ‘construction plan’
avleggs ‘antiquated’
budskap ‘message’
fødsel ‘birth’
forlodds ‘in advance’
forventning ‘expectation’
fredsdagen ‘liberation day’
gammeldags ‘old fashioned’
gløgt ‘smart’ neut.
grovt ‘rough’ neut.
internasjonal ‘international’
jordklode ‘world’
kapital ‘capital’
kommisjon ‘commission’
konkurranse ‘competition’
livserfaring ‘life experience’
livsfarlig ‘perilous’
oppløsning ‘disintegration’
sløvt ‘blunt’ neut.
statsembedsmann ‘government official’
stivt ‘stiff’ neut.
tilfreds ‘satisfied’
tilladds
tilleggsbevis ‘additional proof’
tilskuddsordninger ‘subsidy settlements’
tregt ‘slow’ neut.
trivsel ‘well-being’
trygt ‘safe’ neut.

Appendix B: Dutch wordlist

Target Words:

bakken ‘to bake’

bekken ‘basin’

blaffen ‘to bark’

bluffen ‘to bluff’

brokkelen ‘to crumble’

Brussel ‘Brussels’

dekken ‘to cover’

dokter ‘doctor’

drassig ‘swampy’

drukken ‘to push’

dwaas ‘fool’

dwerg ‘dwarf’

fakkel ‘torch’

fikken ‘to brun’

flappen ‘to fling down’

flikken ‘to get away with’

fractie ‘fraction’

frictie ‘friction’

gaffel ‘fork’

giftig ‘poisonous’

glasplaat ‘plate of glass’

glippen ‘to sneak’

gniffelen ‘to snigger’

gnoe ‘gnu’

grappig ‘funny’

grissen ‘to snatch’

jachten ‘to hurry’

juffrouw ‘madam’

kappen ‘to chop’

kikker ‘frog’

klappen ‘to clap’

klikken ‘to click’

knakken ‘to snap’

knikken ‘to crack’

krachtig ‘strong’

krassen ‘to scratch’

kwakken ‘to crash’

kwetsen ‘to injure’

lachen ‘to laugh’

likken ‘to lick’

machtig ‘powerful’

missen ‘to miss’

nachten ‘nights’

nuttig ‘useful’

pakken ‘to take’

pikken ‘to peck’

plakken ‘to stick’

plukken ‘to pick’

prachtig ‘splendid’

prikken ‘to prick’

raspen ‘to grate’

richten ‘to aim’

sappig ‘juicy’

sissen ‘to hiss’

slachten ‘to slaughter’

slikken ‘to swallow’

smachten ‘to languish’

smikkelen ‘to tuck in’

snakken ‘to gasp’

snikken ‘to sob’

tappen ‘to tap’

tikken ‘to tap, tick’

trappen ‘to step’

trekken ‘to pull’

twaalf ‘twelve’

tweig ‘twig’

vasten ‘to fast’

vechten ‘to fight’

vlakte ‘plain’

vlechten ‘to braid’

vrachten ‘loads’

vruchten ‘fruits’

wakker ‘awake’

westen ‘west’

wrakhout ‘wreckage’

wrikken ‘to lever, prize’

zakken ‘to fall’

zitten ‘to sit’

zwachtel ‘bandage’

zwikken ‘to sprain’

Distractors:

afnemen ‘to take off’

bladgroente ‘green vegetables’

bladzijde ‘page’

bloedvat ‘blood vessel’

braadpan ‘casserole’

breedband ‘broadband’

broodje ‘roll, bun’

dagblad ‘newspaper’

daglicht ‘daylight’

dakloos ‘homeless’

diepzinnig ‘profound’

doodklap ‘death blow’

doodmoe ‘dead tired’

eenvoudig ‘simple’

eerzucht ‘ambition’

heilzaam ‘healing’

huisdier ‘house pet’

huisman ‘househusband’

huiswerk ‘homework’

ijsbeer ‘polar bear’

ingang ‘entrance’

laadbak ‘loading platform’

leefbaar ‘liveable’

losgaan ‘to come loose’

luchtdicht ‘airtight’

noodweer ‘self defense’

oprichten ‘to establish’

opvatten ‘to interpret’

wegslaan ‘to hit away’

zakdoek ‘handkerchief’

Appendix C: Swiss German wordlist

Target Words:

bache ‘to bake’
bätte ‘to pray’
Blache ‘tarp’
bläche ‘to pay’
bräche ‘to break’
braschte ‘to boast’
Chappe ‘hat’
chätsche ‘to chew’
chlappere ‘to chatter’
chlüpfig ‘easily scared’
chnätte ‘to knead’
Chnoche ‘bone’
chräschle ‘to rustle’
chratze ‘to scratch’
dachlos ‘homeless’
decke ‘to cover’
Drache ‘dragon’
dräckig ‘dirty’
fasse ‘to grasp’
fecke ‘to check’
fläcke ‘to go astray’
flatterig ‘flighty’
Frachter ‘freighter’
frässe ‘to eat’
Gattig ‘sort’
geschter ‘yesterday’
glatti ‘smooth’ fem.
glücklech ‘happy’
gnappe ‘to tip’
gnepfe ‘to wobble’
grapsche ‘to grope’
Griffe ‘grips’
Kasse ‘register’
Käthi ‘Kathy’
klappe ‘to work’
kläre ‘to explain’
knackig ‘crisp’
Knöchel/Chnöchu ‘ankle/joint’
krache ‘to make noise’
Krise ‘crisis’
lache ‘to laugh’
lüpfe ‘to lift’

mache ‘to make’
mische ‘to mix’
nache ‘after, behind’
nütze ‘to make use of’
packe ‘to pack’
Pfäffer ‘pepper’
Pflaschter ‘plaster’
pflücke ‘to pick’
Pfnüsu ‘the sniffles’
pfropfe ‘to plug’
pfupfe ‘to snicker’
picke ‘to pick’
platsche ‘to pour’,
plättere ‘to lie around’
prächtig ‘splendid’
praktisch ‘practically’
Rappe ‘unit of currency’
richte ‘to direct’
Sache ‘matters’
schaffe ‘to work’
schicke ‘to send’
schlachte ‘to slaughter’
schlücke ‘to swallow’
schmatzge ‘to eat loudly’
schmöcke ‘to smell’
Schnägge ‘snails’
schnappe ‘to snatch’
Schratte ‘crack’
Schrecke ‘terror’
schwache ‘to become weak’
Schwöschter ‘sister’
sicher ‘sure’
tapfer ‘brave’
tätsche ‘to land, bang’
Trachte ‘costumes’
träffe ‘to meet’
Vatter ‘father’
Vetter ‘cousin’
Wasser ‘water’
Wätter ‘weather’
Zagge ‘prong’
Zwätschge ‘plum’
zwüsche ‘in between’
Zyschtig ‘Tuesday’

Distractors:

aalose ‘to listen to’

abegheie ‘to fall down’

abelade ‘to download’

Abstimmig ‘vote’

Bundeshus ‘federal parliament building’

Burehüser ‘farm houses’

Gmeind ‘community’

Gnosseschaft ‘association’

göögge ‘to vomit’

Gsundheit ‘health’

Himelgüegeli ‘lady bug’

Houptsach ‘main point’

Huuffe ‘heap’

näbenab ‘sideways’

nachegfragt ‘asked’

Nastuech ‘facial tissue’

Phase ‘phase’

schnuufe ‘to breathe’

Trinkgäld ‘tip’

ufestyge ‘to climb up’

ungerwägs ‘on the way’

zletschtamänd ‘finally’