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*Swiss German stops : geminates all over the word**

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This paper presents evidence for two claims: (a) that the underlying contrast between stops in Swiss German dialects is based purely on quantity and (b) that the duration of the stop closure is its sole reliable phonetic reflex, i.e. there is a geminate–singleton opposition acoustically manifested in long–short closure duration. Using production and perception data on initial, medial and final stops in Thurgovian, a dialect spoken in north-eastern Switzerland, we show that the pattern of phrase-medial contrast neutralisation supports both arguments: when the extra *phonological* length position of a geminate is not syllabifiable, the closure duration shortens and underlying geminates and singletons become indistinguishable. The perception data in particular make evident that closure duration is the crucial cue of the underlying contrast, because, in the absence of this phonetic correlate, listeners can no longer discriminate an underlying geminate from a singleton. The results bear not only on central issues concerning the representation of geminates but also on some intricacies of the phonology–phonetics interface.

1 Introduction

Quantity as a means of expressing phonological contrast occurs in many languages. Although vowel-length contrasts are more frequent, geminate–singleton consonant contrasts are not rare.[1] Where consonant length is phonemic, the contrast is usually found in word-medial position. The

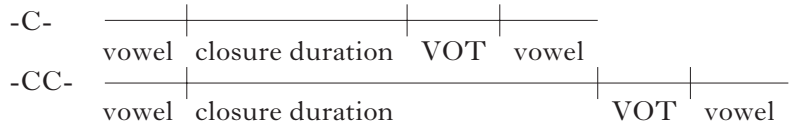
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[1] Although Maddieson (1984) lists 51 out of 317 languages with vowel-length contrasts, and 11 are reported to have consonant contrasts, these numbers are somewhat misleading. Some of the languages reported in the survey do have geminate phonemes, but probably were not listed in the phonemic inventory given in the original source. For instance, Bengali does not appear among the languages with long consonants, although it clearly has geminates.

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most salient acoustic correlate for stop consonant length is closure duration (Lahiri & Hankamer 1988, Hankamer *et al*. 1989, Ladefoged & Maddieson 1996, Cohn *et al*. 1999, and references therein). Schematically, this difference between singleton and geminate voiceless stops can be represented as in (1).

(1) *Schematic difference between singleton and geminate voiceless stops*



Swiss German dialects are interesting in that they show a quantity distinction in word-medial position as well as in word-final and word-initial positions. Word-initial geminates in particular are typologically extremely rare (Hayes 1989, Hume *et al*. 1997, Davis 1999). Derived initial geminates are found, for example, in Malayalam (e.g. Mohanan 1989) and Italian (*raddoppiamento sintattico*; e.g. Lepschy & Lepschy 1988, Ghini 1993). What makes the Swiss German system even more intriguing is the fact that the initial geminates are lexical, i.e. non-derived. Moreover, they can be phonologically distinguished from non-geminates only within a phonological phrase in specific contexts, due to syllabification across word boundaries.

This paper deals with the Swiss German stop geminates: their phonological representation and phonetic properties, particularly the phonetic realisation of the phonological contrast in phrasal context. After a short excursion into the consonant system and syllable structure of Swiss German, exemplified by the dialect of Thurgovian, we will lay out our theoretical assumptions about how the difference between geminates and singletons is represented phonologically. Then, after a discussion of the most relevant literature on Swiss German, we present acoustic data from Thurgovian which show that closure duration as the most salient correlate of quantity is responsible for the different treatment of initial and final stops at phrase boundaries: for the former the distinction cannot be realised while for the latter it is possible. Finally, we will briefly discuss the source of this quantity contrast in Swiss German, a contrast not evident in other Germanic languages.

2 The synchronic consonant system of Swiss German dialects

2.1 The phoneme inventory

From the older stages of the German language, Swiss German dialects have maintained quantity distinctions within the vowels as well as the

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consonants. Thurgovian, the dialect spoken in the canton of Thurgau in north-eastern Switzerland, is an example of such a Swiss German dialect. This dialect displays length oppositions in the consonants shown in (2) (geminate–singleton pairs are highlighted):

(2) *Thurgovian consonant phoneme inventory*

	bilabial	labio-dental	dental	palato-alveolar	velar
stops	pp p		tt t		kk k
fricatives		ff f	ss s	ʃʃ ʃ	xx x
affricates	p^f		t^s		k^x
nasals	mm m		nn n		ŋŋ
laterals			ll l		
rhotics					ʀ
glides	w			j	

Here we will focus on the stop pairs only. As has been found for other Swiss German dialects (see §§4.1–2), laryngeal features such as voicing or aspiration do not take part in the underlying opposition or in the phonetic manifestation of the stops. We will argue that the phonological distinction is purely quantity-based.

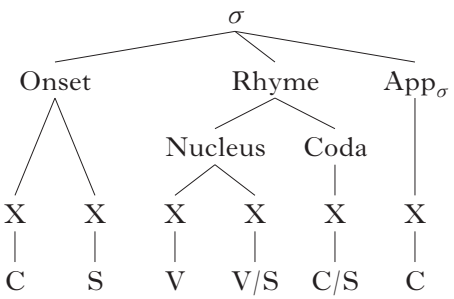
The phoneme contrast in (2) is not realised in all positions of the word. While sonorants and fricatives of opposing quantity are restricted to the middle and the end of words, geminate and singleton stops also occur at the beginning of words. This distribution is partly a remnant of the West Germanic period and partly the result of the incorporation of loanwords after the Old High German Consonant Shift. These historical roots will be discussed in more detail in §5.

2.2 Syllable structure and syllabification

Since the representation and phonological behaviour of geminates relies on syllable structure, it is important to introduce the necessary prosodic facts of the Thurgovian system. The basic syllable template as argued for in Kraehenmann (1996) is given in (3), where V = vowel, S = sonorant consonant and C = obstruent.

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(3)



The last line in (3) indicates the possible distribution of consonants and vowels in the various syllable positions. To start with the rightmost constituent in (3), the issue of a final appendix constituent in German is a contentious one. Accounts which contain this constituent differ greatly not only in detail but also in content (Giegerich 1992, Yu 1992, Wiese 1996, among others). The constituent proposed here is similar to the extrarhymal position proposed for Dutch by Kager & Zonneveld (1986) and adopted by Fikkert (1994). In Thurgovian only coronal obstruents are allowed in the syllable appendix, as in the example *Liecht* 'light' [liəx**t**].[2]

The rhyme contains a maximum of three positions. Evidence for this comes from the fact that non-final syllable rhymes maximally consist of sequences of VVC, VVS or VSC, while sequences of *VVSC or *VVCC are non-existent. VV may be a long vowel or a diphthong. The first nucleus position, which is the only obligatory position, is always linked with a vowel, whereas the second can be a sonorant consonant. Obstruents, however, can *never* occupy a nuclear position. The coda position is always consonantal, and may be branching under the condition that (a) the nucleus is not branching and (b) the coda segment is a geminate.

The onset may be branching as well. The first slot typically is occupied by an obstruent, the second slot typically by a liquid but may contain a nasal consonant as well.

Following Itô (1986: 3–7), we assume that segments must be licensed, i.e. belong to a higher level of prosodic structure, in order to become available for phonetic interpretation. Segments are prosodically licensed when they are syllabifiable, which means that they can be mapped to the positions on the template. Edges of well-defined prosodic domains – here the edges of phonological words at a phonological phrase boundary – are special in that they allow certain material which cannot be mapped to

[2] As claimed for Dutch by Kager & Zonneveld (1986), we assume for Swiss German an additional appendix adjacent to the syllabic appendix. It is attached at the prosodic word level and its content is also restricted to coronal obstruents. There are a number of different views on this constituent, but we cannot go into them here (see Kraehenmann 1996 for more detail).

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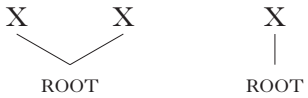
syllable structure to remain.[3] Such segments are extraprosodically licensed by being linked to the phonological word directly. Any unlicensed phonemic material is deleted by Stray Erasure.[4]

3 The phonological representation of geminates: assumptions and predictions

Assuming that segment length is represented not as a feature (cf. Kenstowicz & Pyle's 1973 seminal contribution), we propose to represent geminates as a single root node linked to two timing slots on a skeletal tier (e.g. Clements & Keyser's 1983 CV slots, Levin's 1985 X slots), as illustrated in (4).[5]

(4) *The representation of Thurgovian geminates and singletons*

a. geminate b. singleton



If we accept the syllable template in (3), prosodic licensing and syllabification across word boundaries, then the representation in (4) makes certain general predictions regarding syllabification and contrast neutralisation, since there are scenarios in which only one geminate slot can be syllabified and the other is possibly deleted (= contrast neutralisation). The predictions are those in (5).

[3] The fact that in general more material is tolerated at domain edges than within domains has been recognised by many (e.g. Itô 1986, Blevins 1995 and references therein; for Dutch, Kager & Zonneveld 1986 and Trommelen 1993; for German, Wiese 1996). It is usually glossed over that unsyllabifiable material can often not be incorporated at the foot level either. We assume as the relevant domain for extraprosodic licensing the phonological word (ω) – the output of the lexical component (if one assumes Lexical Phonology) – at the edge of a phonological phrase.

[4] Ample motivation for Stray Erasure can be found for example in McCarthy (1979), Steriade (1982) and Harris (1983).

[5] There are other alternatives, such as representing geminates as inherently weight-bearing (e.g. Hayes 1989) or consisting of two separate root nodes (e.g. Selkirk 1991). For a recent discussion on the advantages and disadvantages of the different representations see Broselow (1995).

The problem essentially concerns the representation of initial geminates. In the account presented here we leave open the issue of moraicity (i.e. weight) of Swiss German geminates. Suffice it to say that there is some evidence suggesting that only word-final geminates, if any, are moraic. Monosyllabic words in Swiss German need to be bimoraic: in /CVC/ roots the vowel is lengthened [CVVC] while /CVCC/ roots surface as such [CVCC]. In this case geminates pattern together with consonant clusters. As will become clear in the discussion in §4.3.2, segment length (i.e. quantity) is at issue rather than weight, and the skeletal framework is ideally suited to capture the phonological patterns of the data at hand.

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(5) *Predictions*

a. The quantity contrast is maintained in intersonorant context for consonants in initial,[6] medial and final word position.
b. For final consonants: the contrast is neutralised iff
   i. the preceding nucleus is branching and
   ii. an obstruent-initial word follows.
c. For initial consonants: the contrast is neutralised after an obstruent-final word.[7]
d. At phrase edges the quantity contrast may be maintained (proviso: extraprosodic licensing of extra geminate slot).

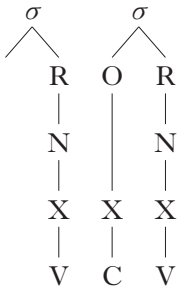
To illustrate these predictions, we look at the different word positions in turn, parallelling the data presentation in §4.3.2.

According to (5a), a phrase-medial opposition in intersonorant context should be maintained. This is represented in (6), where C represents the root node of stop consonants.

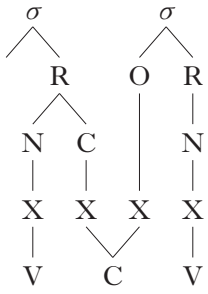
(6) *Phrase-medial intersonorant consonants*

a. after non-branching nucleus: opposition maintained

/VCV/ → [VCV]



/VCCV/ → [VCCV]



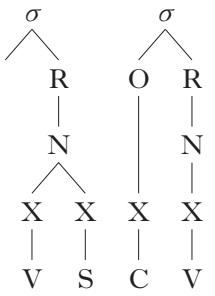
[6] For word-initial consonants, this statement needs to be qualified. There is a case where we predict neutralisation of the contrast in intersonorant context, namely if word-initial stop consonants are preceded by a sonorant which must be syllabified in the coda, i.e. a sonorant preceded by a branching nucleus (e.g. *Schuum* [ʃuum] 'foam', *Helm* [helm] 'helmet'). This predication cannot be verified since our data presented in §4.3.2 unfortunately only include instances where the sonorant can be syllabified in the nucleus, as depicted in (6b).

[7] Note that this would also hold after an obstruent-final *prefix* (e.g. /mi**s-t**üütt -ə/ [mi**st**üüttə] 'to misinterpret' *vs.* /mi**s- tt**öön -ə/ [mi**st**öönə] 'to sound unpleasant') and similarly above in (5b.ii) if an obstruent-initial *suffix* follows (/kk- kˣi**pp -tt**/ [kˣi**pt**] 'toppled (PART)' *vs.* /kk- lɛ**p -tt/** [klɛ**p**t] 'lived (PART)'). The terminology was chosen to fit phrasal contexts for which we have acoustic data (cf. §4.3.2). Morphologically complex words are not included.

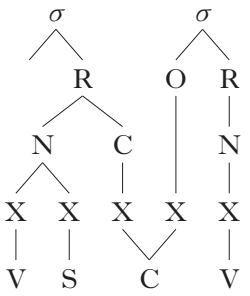
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b. after branching nucleus: opposition maintained

/VSCV/ → [VSCV]



/VSCCV/ → [VSCCV]



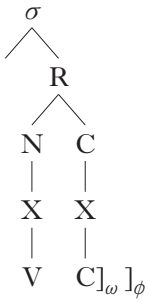
The representations in (6) are intended to include word-medial consonants, which by definition are phrase-medial, and intersonorant contexts for word-final and word-initial consonants across words within a phrase. Note that underlying sequences of /VVC(C)V/ would have the same syllabic structures as in (6b).[8] Also, when the segment *following* the stop consonant is a sonorant the opposition is still maintained.

For the contrast in word-final position we have to distinguish between phrase-final and phrase-medial contexts. At a phrase boundary, we expect that the opposition may be maintained, even after a branching nucleus, as depicted in (7b). The extra geminate position is licensed at the phonological word level since it is at the edge of the syllabification domain.[9]

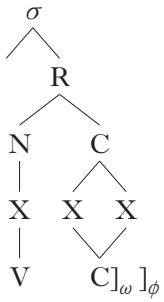
(7) *Word-final consonants at phrase boundary*

a. after non-branching nucleus: opposition maintained

/VC#/]$_\phi$ → [VC]]$_\phi$



/VCC#/]$_\phi$ → [VCC]]$_\phi$



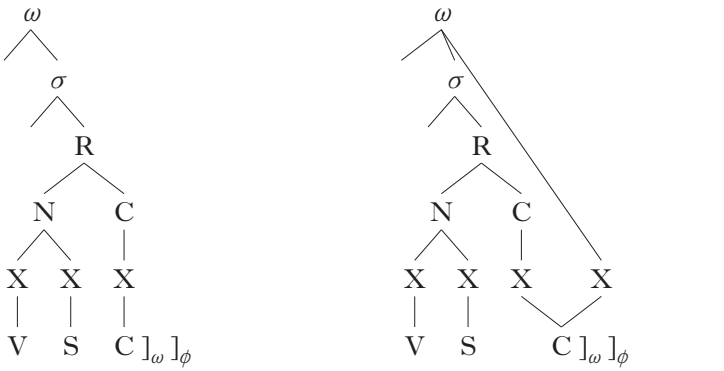
[8] For the remainder of the paper, branching nuclei from sonorant consonants or vowels will be treated the same, since, to all intents and purposes, they *are* the same here.

[9] Note that we are *not* assuming that there is no structure between the syllable and the word level. For reasons of space the foot level has been omitted, since it does not play any role here.

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b. after branching nucleus: opposition maintained

/VSC#/]$_\phi$ → [VSC]]$_\phi$ /VSCC#/]$_\phi$ → [VSCC]]$_\phi$



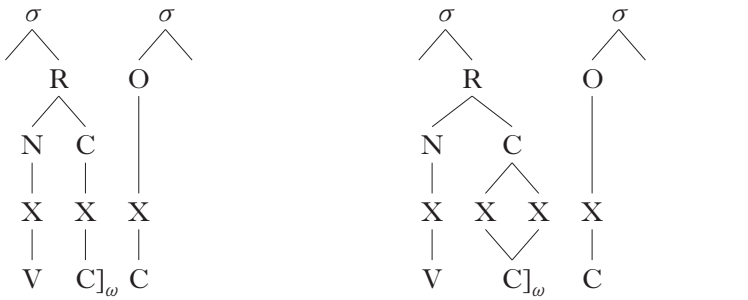
Phrase-medially, according to (5b), contrast neutralisation is predicted only if the next word starts with an obstruent and the preceding nucleus is branching (see (8b)): the second geminate slot cannot be mapped to the following onset because it already contains an obstruent segment; it cannot be mapped to the coda either because the three available positions are already occupied. The result is Stray Erasure of the unlinked timing slot, which should lead to geminate shortening.

Word-final consonants before vowel- and sonorant-initial words should behave as medial consonants: the distinction is kept both after branching and non-branching nuclei (cf. (6)).

(8) *Word-final consonants within phrase: before an obstruent-initial word*

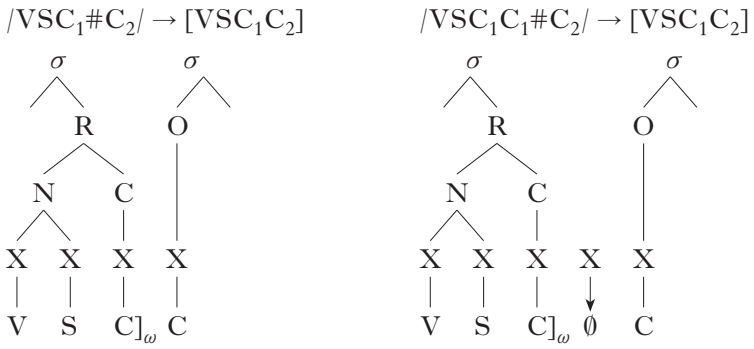
a. after non-branching nucleus: opposition maintained

/VC$_1$#C$_2$/ → [VC$_1$C$_2$] /VC$_1$C$_1$#C$_2$/ → [VC$_1$C$_1$C$_2$]



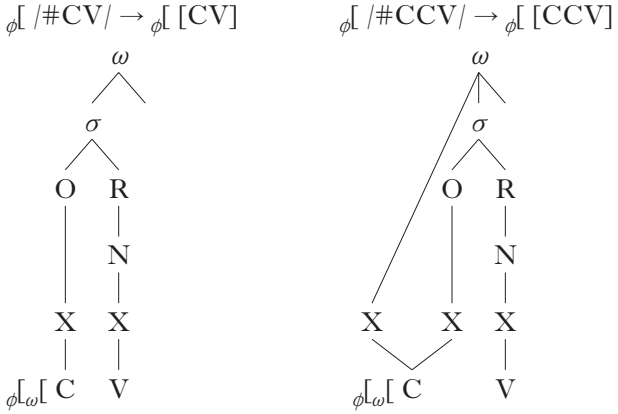
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b. after branching nucleus: opposition neutralised



For the geminate–singleton opposition in word-initial position we again distinguish cases at phrase boundaries from those within phrases. Phrase-initially the situation would be as in (9).

(9) *Word-initial consonants at phrase boundary: opposition maintained*

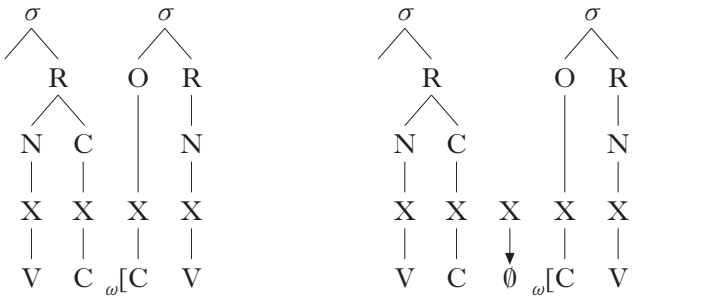


In absolute phrase-initial position we expect geminates and singletons to be distinguishable, because the first timing position of a geminate is licensed at the phrase edge. They should also be distinguishable phrase-medially in intersonorant context, just like the medial and final consonants. After an obstruent-final word, however, we predict neutralisation as for final consonants (10).

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(10) *Word-initial consonants within phrase: after an obstruent-final word*

$/VC_1\#C_2V/ \rightarrow [VC_1C_2V]$ $/VC_1\#C_2C_2V/ \rightarrow [VC_1C_2V]$



What is different from final consonants is the fact that the geminate adjacent coda may not be branching: it is not possible to syllabify the *entire* geminate in the coda, as is the case in (8a).

Whether these phonological predictions are actually borne out by the phonetics of Swiss German is the object of discussion in the following section, in which we present production data from the dialect of Thurgovian. The conclusions we reach concerning the analysis of initial stops are substantiated by a perception experiment.

4 Phonetics of consonant duration

Before discussing the phonetics of Thurgovian geminates, we consider the existing literature on this distinction in Swiss German. This literature sets the stage for the data and acoustic analysis of Thurgovian in §4.3. It can be divided into two main fields, namely dialect descriptions and acoustic studies.

4.1 Dialect descriptions

Dialect descriptions of Swiss German (e.g. Winteler 1876, Berger 1910, Vetsch 1910, Enderlin 1913, Streiff 1915, Wiget 1916, Wanner 1941, Moulton 1986) agree that the obstruent consonants of the dialects are all voiceless and that one of the major distinctions within the consonants is based on the concept of FORTIS *vs.* LENIS. As Braun (1988) reports in detail and Willi (1996: 9–11) and Ham (1997: 18–21, 1998: 81–85) summarise with particular reference to High Alemannic, the terms fortis and lenis are notorious for referring to different concepts. The Swiss German literature is no exception. The basic controversy in the literature is whether the opposition is one of intensity or duration. Winteler (1876: 22), who

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described the phonological distinction as 'quantitative' as opposed to 'qualitative', the fortis consonants being *Verdoppelungen*, i.e. doublings of the lenis ones, served as an authoritative reference for many subsequent descriptions of Swiss German dialects. According to Winteler, a fortis sound is pronounced with more energy of expiration and articulation than its corresponding lenis sound and, as a consequence of this additional energy, displays a longer duration. Hence, the terms degree of strength, intensity and amount of energy are used interchangeably in the dialect descriptions referred to above to describe the nature of the fortis–lenis distinction.

Broadly speaking, the term 'geminate' has been used in the literature for fortis consonants when occurring in an intersonorant context in addition to belonging to two adjacent syllables, as for example the bilabial stop in the word *Chappe* [xap.pe] 'cap' (Berger 1910: 12, Vetsch 1910: 20, Enderlin 1913: 9, Streiff 1915: 13, Wiget 1916: 11, Wanner 1941: 11). In other contexts fortis consonants have been labelled as merely 'fortis' and not geminate, which is also often reflected in single letter spelling. In contrast, we use 'geminate' here to refer to underlying doubly linked segments, as in (4a).

4.2 Acoustic studies

In the literature, the few acoustic studies concerned with Swiss German dialects (e.g. Dieth & Brunner 1943, Brunner 1953, Enstrom & Spörri-Bütler 1981, Fulop 1994, Willi 1996, Ham 1997, 1998)[10] aim at determining the primary and secondary phonetic correlates of the fortis–lenis distinction, where 'primary' means the acoustic characteristic(s) relevant for the underlying, i.e. phonological contrast, and 'secondary' refers to ancillary acoustic features.

The earliest study (Dieth & Brunner 1943), on a number of different Swiss German dialects, found that intra-oral pressure is stronger in fortis consonants, but the actual pressure difference is highly speaker-dependent, with fortis being between 1·17 and 2·7 times as strong as lenis. Duration measurements, though, show solid and consistent length differences, with fortis stops being almost three times as long as lenis ones. Dieth & Brunner (1943) mention that the duration of consonants is dependent on a number of factors, paramount among which are (a) the length of the preceding vowel – fortis consonants after short vowels are on

[10] Most acoustic investigations have been done on speech samples of native speakers of the dialect of Zurich (Dieth & Brunner 1943, Brunner 1953, Enstrom & Spörri-Bütler 1981, Fulop 1994, Willi 1996). The very scant data from others include the dialects of Schaffhausen and Thurgau (Dieth & Brunner 1943) and Bern (Ham 1997, 1998). A study by Spaelti (1994) deals with geminates of a dialect spoken in the canton of Glarus, though not in an acoustic framework, and is therefore not discussed here.

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average 25 % longer than after long vowels, (b) the position within the word (medial consonants are longest while initial ones are shortest) and (c) the position relative to word stress: consonants are longer in stressed syllables than in unstressed ones.[11]

The duration of a preceding stressed vowels is also an important factor in the study of Willi (1996), on post-tonic stops of the Zurich dialect.[12] While the production experiment is reported to have produced evidence that fortis stops on average are 70 % longer than lenis ones, in addition to the former being 11 % and the latter 14 % longer after stressed than after unstressed vowels, the perception experiment resulted in the ratio between the absolute duration of the stressed vowel and the following consonant being decisive for the fortis–lenis distinction in the consonants.

Based on data from the Zurich dialect, Brunner (1953) argues for closure duration being a co-defining characteristic of the fortis–lenis opposition, alongside tension. This is a notion also advocated and elaborated by Kohler (1979, 1984) with respect to the nature of fortis–lenis systems in general, namely that none of the phonetic correlates – aspiration, voicing, pressure and closure duration – is by itself responsible for implementing the phonological [±fortis] feature, but rather a combination of these parameters, which are weighted differently for any particular language. In another study on the Zurich dialect, Fulop (1994) also finds that closure duration is not the only acoustic correlate. While medial and final fortis stops are up to four times longer than lenis ones,[13] duration is neutralised in initial position. Fulop hypothesises, however, that the phonological contrast can possibly still be recovered in this position by the secondary correlates he found. He claims that the post-release sonorant formants above F2 consistently show increased intensity, movement and clarity following fortis, but not lenis, stops.

As in the dialect descriptions mentioned above, voicing has been found in acoustic studies not to be relevant phonological factor. Brunner (1953) mentions that the lenis consonants of the Zurich dialects he investigated are voiced in certain environments but that this voicing is not phonologically significant, since it is most evident in stops as opposed to fricatives and also fortis consonants tend to sonorise. Similarly, in their

[11] Dieth & Brunner (1943) do not explicitly state what they mean by 'duration' and it is not readily inferable. Nonetheless, we assume that they use the term as meaning duration of the closure (CD), i.e. not including voice onset time (VOT), which is how duration is understood in general in this context.

[12] The data in our study on Thurgovian did not show any evidence that preceding vowel length is crucial. The CD of singletons after long vowels is on average 67·8 ms, after short vowels 58·7 ms (difference not significant: $F_{(1,127)} = 1{\cdot}01$, $p = 0{\cdot}3177$); the CD of geminates after long vowels is on average 148·0 ms, after short vowels 145·8 ms (difference not significant: $F_{(1,131)} = 0{\cdot}36$, $p = 0{\cdot}5480$). Thus, preceding vowel length has no influence on the closure duration of the following consonant. Willi's (1996) data contains in parts questionable material from a reading task: speakers had to read a list of 215 logatoms in which the medial geminate and singleton consonants were preceded by all the possible long and short vowels of the Zurich dialect. Moreover, only 19·5 % of these words (42 items) were actual words.

[13] How the duration of stops is measured is explained at the end of §4.3.1.

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study on word-initial Swiss German stops, Enstrom & Spörri-Bütler (1981) find that voice onset time (VOT) is not distinctive: the values for fortis and lenis stops overlap within the same places of articulation, with a difference between means of around 2 ms. In Fulop's (1994) study on Zurich initial, medial and final stops, VOT is virtually identical for fortis and lenis consonants, and no voicing was found in the closure period. Although Ham (1997, 1998) also concludes that for Bernese obstruents VOT is not contrastive, he makes the proposal that the fortis–lenis opposition constitutes an underlying voicing contrast in which the phonological feature [voice] is phonetically implemented as short closure duration. Thus, as he states a number of times, the defining characteristic – even though couched in voicing terminology – is actually length, distinguishing between geminates, i.e. long consonants, and singletons, i.e. short consonants, at the (phonological) suprasegmental level.

The following acoustic investigation of Swiss German stops will serve to test our assumptions on the geminate–singleton contrast and our expectations on asymmetries with respect to different phrasal positions. Looking only at citation forms of words, therefore, is not enough for these purposes: words in precisely defined contexts are also needed. We will begin by describing the material and then provide the measurements, discussing the phonetic manifestation of the underlying phonological contrast.

4.3 Thurgovian data

4.3.1 *Methods and stimuli.* A list of words was compiled with all the contrasting stop consonants (see the inventory in (2) above) in word-medial, word-final and word-initial positions. The words with medial and initial consonants were bisyllabic with initial stress (e.g. *Súppe* 'soup', *Kótlett* 'cutlet')[14] and the words with final consonants were monosyllabic (e.g. *nett* 'nice'), so that in all non-initial cases a stressed vowel preceded the consonants under investigation.[15]

[14] Swiss German is not usually written. We stay as close to the Standard German orthography as possible. Where the sounds of Swiss German and Standard German deviate and the phonetic form is not crucial, we write the letters with the Standard German sound correspondence in mind. To help clarify the various position-dependent spellings of the stops, we give the phoneme-to-grapheme correspondences below:

(i)	*initial*	*medial*	*final*		*initial*	*medial*	*final*
/pp/	p	p(p)	p(p)	/p/	b	b	b
/tt/	t	t(t)	t(t)	/t/	d	d	d
/kk/	k	gg/ck	(c)k/gg	/k/	g	g	g

[15] There exist bisyllabic words with final stress, e.g. *Tablett* 'tray' [ta'plɛtt]. However, many of these words optionally receive initial stress like ['taplɛtt]. This trochaic pattern is the regular and predominant one in Thurgovian. To avoid the problem of variation altogether we opted to choose monosyllabic words with word-final consonants.

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The medial stops were preceded by long and short vowels (e.g. *huupä* 'to honk', *Suppe*), and occurred in clusters with sonorant consonants (e.g. *Lampe* 'lamp'). The stops at the word margins were as follows: initial stops were followed by a short or long vowel or a sonorant consonant (e.g. *Pomfrit* 'French fries', *B*[oo]*ne* 'bean', *Trube* 'grape'; final stops were preceded by a long vowel or a sonorant consonant (e.g. *R*[aa]*b* 'raven', *Chalb* 'calf'). All words were recorded in citation form, the words with initial and final stops additionally in the three different phrasal contexts after/before a vowel, a sonorant or an obstruent. These various conditions are summarised in Table I, which gives example word pairs and the phrasal context words for illustration. In total, there were 46 test items containing stops (12 initial, 22 medial, 12 final; sample items are listed in Appendix A).

(a)		*geminate*		*singleton*	
initial stops in *σ́ σ*	$_{\phi}$[__	/pp/omfrit	'French fries'	/p/ohne	'bean'
	__V̆	/tt/**u**rte	'layer cake'	/t/**o**tter	'egg yolk'
	__V̄	—		/p/**oh**ne	'bean'
	__S	/tt/**r**ube	'grape'	/t/**r**aschee	'coated pill'
medial stops in *σ́ σ*	V̆__	S**u**/pp/e	'soup'	St**u**/p/e	'living room'
	V̄__	h**uu**/pp/ä	'to honk'	H**uu**/p/e	'hood'
	S__	To**l**/kk/e	'smudge'	fo**l**/k/ä	'to obey'
	__V̆	Hoo/kk/**e**	'hook'	Bo/k/**e**	'arch'
final stops in *σ́*	V̆__	schl**a**/pp/	'limp'	—	
	V̄__	T**aa**/tt/	'deed'	R**aa**/t/	'wheel'
	S__	a**l**/tt/	'old'	Wa**l**/t/	'forest'
	__]$_{\phi}$	schla/pp/	'limp'	Raa/p/	'raven'
(b)	V̆#__	h/**a**/	'I have'		
	S#__	vi/**l**/	'a lot'		
	C#__	weni/**k**/	'little'		
	__#V̄	/**aa**/	'on'		
	__#S	/**l**/ernä	'learn'		
	__#C	/**k**/sait	'said'		

Table I

Example word pairs for contexts and conditions of recorded test vowels: (a) within words; (b) across words.

Three male native speakers of the dialect of Thurgovian were recorded in a sound-proof booth, where they completed the task twice. There were three parts to the task.

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First, for the citation condition, the speakers produced each word, reading off a computer screen after having seen the word in a semantically relevant written context immediately beforehand. The prompted word could be in any position in the context. The semantic context aimed primarily at familiarising the subjects with the written form of the words, because people are not normally used to Swiss German in written form. An example is given in (11).

(11) *Citation set-up*

Semantic context on screen (*to be read silently*)

mit Pfiil und Boge
with arrow and bow
'with bow and arrow'

Prompt on screen (*to be read aloud*)

Boge

For the items in phrasal context, the task was as follows: the subjects were first given a question to read silently off the computer screen, after which they were prompted with a single stimulus. This stimulus had to be put into an empty slot within an answer sentence, which served as the carrier phrase. The schema of the answer sentence was given in printed form on a sheet of paper. There were three questions, each with matching answer sentences for items with initial and final stops. Below we give one of the questions and the corresponding sentence the speakers had to produce for initial stops (12a) in the second part of the task, and for final stops (12b) in the third part of the task (for the whole set of question and answer sentences see Appendix B).

(12) *Question–answer set-up*

a. *for word-initial stops*

Question on screen

Häsch das gern?
have you this like
'Do you like this?'

Prompt on screen

Gurke

Schema of answer sentence

Ich ha __ nöd gern
I have not like
'I don't like __.'

b. *for word-final stops*

Question on screen

Weles Wort wöt er lernä?
which word wants he learn
'Which word does he want to learn?'

Prompt on screen

schlapp

Schema of answer sentence

Er wöt s Wort __ lernä
he wants the word learn
'He wants to learn the word __.'

The subjects had to pick the appropriate answer to the question given and had to say it spontaneously. They did *not* read the answer sentence off the computer screen. Because of the complexity of the task, the speakers practised with non-target items until they felt comfortable with the task,

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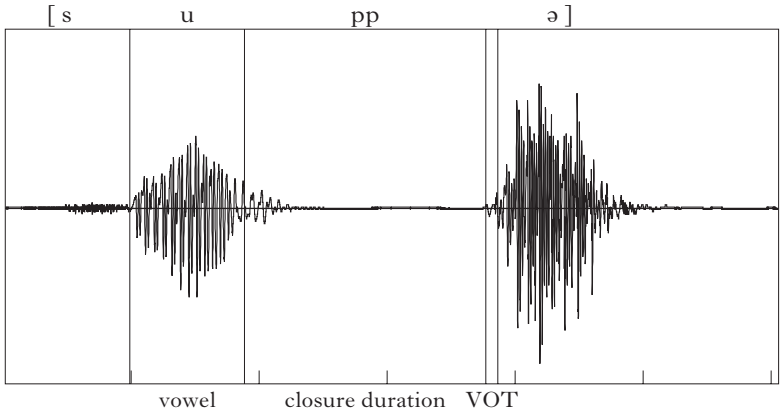


Figure 1
Measurement marks for the target item *Suppe* 'soup' (speaker 3).

so as to maximise the naturalness of the speech samples that were subsequently recorded.

For the subsequent acoustic measurements we rejected speech samples which contained substitutions, stutters and hesitations in the crucial positions and those tokens that showed contact geminates stemming from place assimilation across word boundaries. Of the 708 possible tokens (3×236), 611 were accepted for the analyses. The distribution among the three speakers is 212, 199 and 200 tokens, respectively.

An example of how the measurement marks were set for the word-medial stops is given in Fig. 1. The starting mark of the closure duration is set at the offset of the preceding sound, here a vowel. The end mark is at the start of the closure release and coincides with the starting mark of the voice onset time, which ends with the onset of the following sound, here also a vowel. The marks for the word-final and word-initial stops in context are set in the same fashion. There is only a difference for words in citation form, i.e. in absolute phrase-final or phrase-initial position: for final consonants, which were audibly released throughout, the end mark is at the offset of the release burst; for initial consonants the starting mark of the voice onset time constitutes the first usable demarcation since no starting mark of the closure duration could be set.

4.3.2 *Results and discussion.* The material presented in this section show that voice onset time (VOT), i.e. the duration of the stop release, is not an acoustic property which distinguishes between geminates and singletons. Closure duration (CD), however, is the single most important factor. Analyses of variance (ANOVA), by speaker and by items, were run independently. VOT and CD were dependent variables, speaker and target were random factors, condition was a first factor. Environment was also included as first factor for calculations involving the entire data set.[16]

[16] Significance is computed at the 5% level; * indicates significant values.

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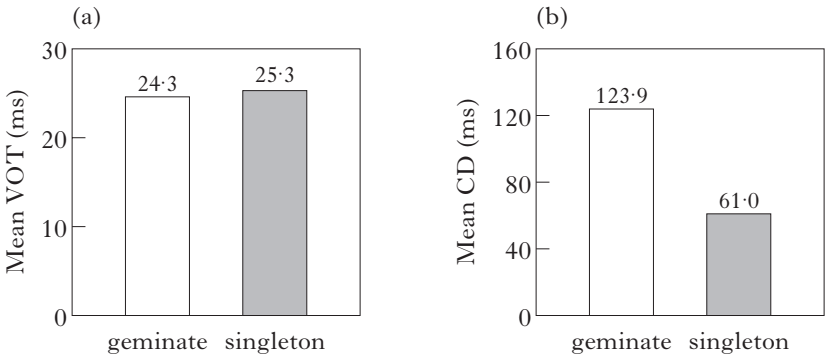


Figure 2

(a) Mean voice onset time in ms, across all data, for geminates (e.g. *huu*/pp/*ä*) and singletons (e.g. *Huu*/p/*e*). The difference is not significant. (b) Mean closure duration in ms, across all data, for geminates and singletons. The difference is significant.

	number of items	Mean VOT $F_{(DF, DF\,den)}$	p	Mean CD $F_{(DF, DF\,den)}$	p
geminate	297	$F_{(1, 595)} = 0{\cdot}36$	0·5493	$F_{(1, 525)} = 465{\cdot}73$	<0·0001*
singleton	314				
total	611				

Table II

Statistical results for data in Fig. 2. (DF = degrees of freedom; den = denominator; p = probability; * = difference is significant.)

4.3.2.1 *Entire data set.* To get an overall sense of the investigated material we first examine the entire set of stop data across all speakers and conditions. The results of these data are summarised in the graphs in Fig. 2, with the statistical results of the ANOVA test in Table II.

Figure 2a shows the mean VOT is virtually the same for geminates and singletons. The 1 ms difference between 24·3 ms and 25·3 ms is statistically irrelevant. In contrast, the difference in mean CD depicted in Fig. 2b is highly significant: the average CD of the geminates is double that of the singletons.

This general outcome suggests on the one hand that CD is the prime acoustic correlate for the underlying distinction in the stops and on the other hand that VOT plays no role whatsoever, as has been claimed for Swiss German dialects other than Thurgovian (e.g. Enstrom & Spörri-Bütler 1981, Ham 1997, 1998). Both these hypotheses are substantiated by the increasingly more detailed analyses below.

4.3.2.2 *All data by position.* Let us first consider what the differences are for stops in initial, medial and final word-position. Figure 3a essentially shows the same picture within categories as Fig. 2a across categories: the differences in VOT are not significant while the ones in CD are. What the

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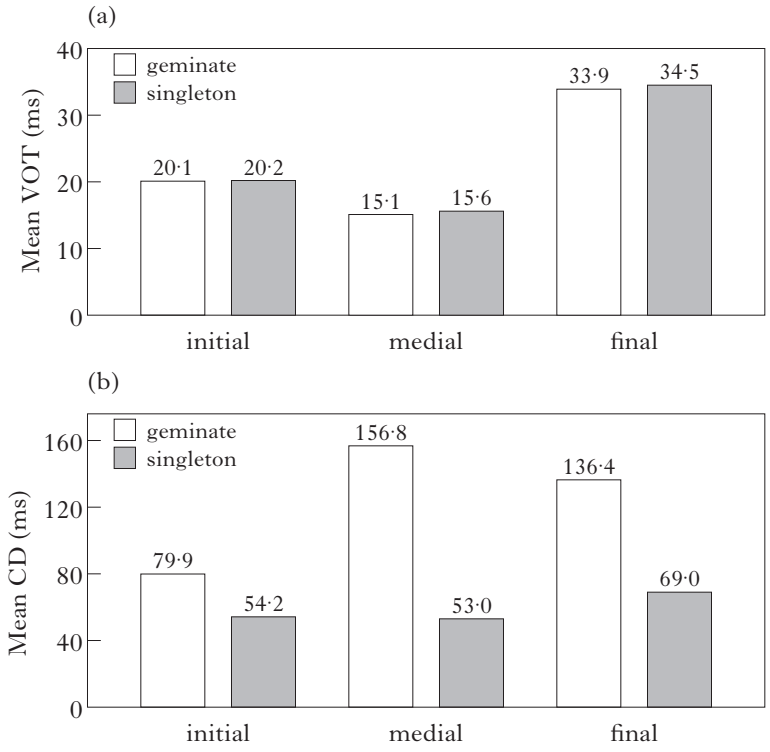


Figure 3

(a) Mean voice onset time in ms for stops in different word positions across all data: initial (e.g. /pp/*omfrit*, /p/*ohne*), medial (e.g. *huu*/pp/*ä*, *Huu*/p/*e*) and final (e.g. *Ta*/tt/, *Ra*/t/). The differences within positions are not significant. (b) Mean closure duration in ms for stops in different word positions across all data. The differences within positions are significant.

	number of items	Mean VOT $F_{(DF, DF\,den)}$	p	Mean CD $F_{(DF, DF\,den)}$	p
initial	234	$F_{(1, 223)} = 0{\cdot}00$	0·9472	$F_{(1, 152)} = 35{\cdot}60$	<0·0001*
medial	130	$F_{(1, 125)} = 0{\cdot}35$	0·5553	$F_{(1, 125)} = 907{\cdot}01$	<0·0001*
final	247	$F_{(1, 236)} = 0{\cdot}31$	0·5757	$F_{(1, 236)} = 259{\cdot}61$	<0·0001*
total	611				

Table III

Statistical results for data in Fig. 3.

figures have in common is the fact that there are considerable differences across categories: VOTs are shortest word-medially and longest word-finally; CDs are shortest word-initially and longest word-medially for

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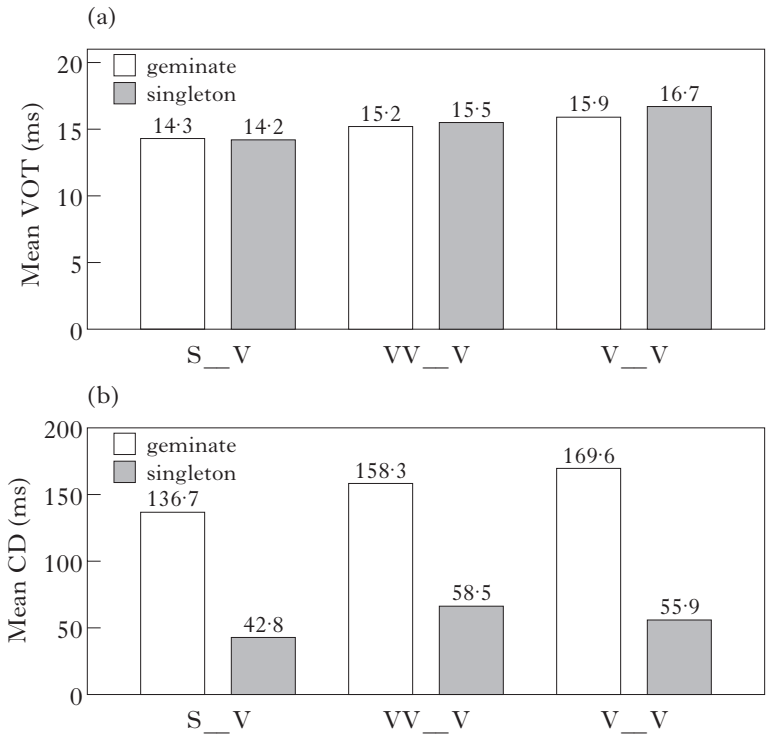


Figure 4

(a) Mean voice onset time in ms for word-medial stops, distinguished by environment: S__V (e.g. *Lam*/pp/*e*, *Bom*/p/*e*), VV__V (e.g. *huu*/pp/*ä*, *Huu*/p/*e*) and V__V (e.g. *Su*/pp/*e*, *Stu*/p/*e*). The differences are not significant. (b) Mean closure duration in ms for word-medial stops, distinguished by environment. The differences are significant.

	number of items	Mean VOT $F_{(DF, DF\,den)}$	p	Mean CD $F_{(DF, DF\,den)}$	p
S__V	36	$F_{(1,32)} = 0{\cdot}00$	0·9672	$F_{(1,32)} = 146{\cdot}81$	<0·0001*
VV__V	47	$F_{(1,42)} = 0{\cdot}04$	0·8469	$F_{(1,42)} = 419{\cdot}29$	<0·0001*
V__V	47	$F_{(1,42)} = 0{\cdot}20$	0·6578	$F_{(1,42)} = 474{\cdot}12$	<0·0001*
total	130				

Table IV

Statistical results for data in Fig. 4.

geminates, while they are shortest word-medially and longest word-finally for singletons.

As will become evident, this difference in *phonetic* length for the three word positions correlates with the *phonological* environment (segmental

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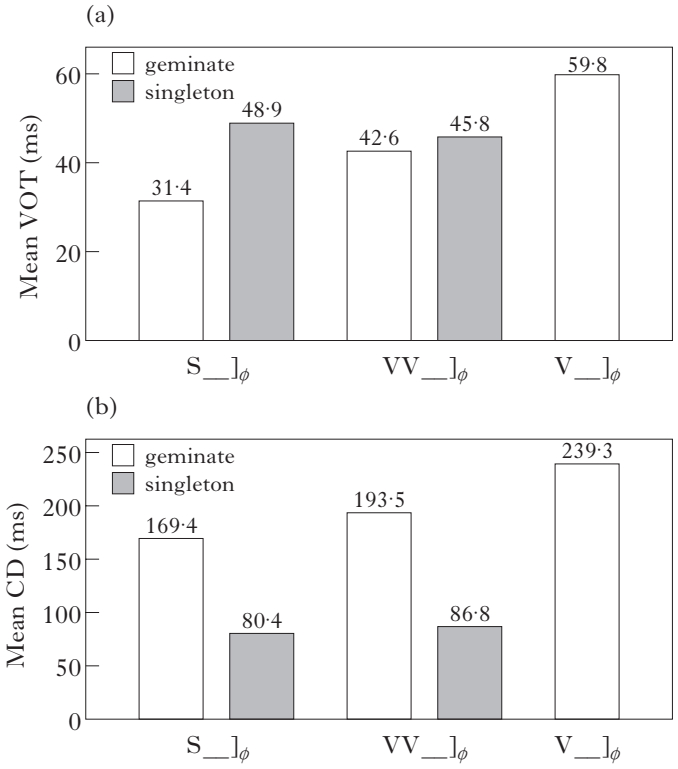


Figure 5

(a) Mean voice onset time in ms for word-final phrase-final stops, distinguished by environment: S__]$_\phi$ (e.g. *al*/tt/, *Wal*/t/), VV__]$_\phi$ (e.g. *Ta*/tt/, *Ra*/t/) and V__]$_\phi$ (e.g. *ne*/tt/ 'nice'). The differences are not significant. (b) Mean closure duration in ms for word-final phrase-final stops, distinguished by environment. The differences are significant.

	number of items	Mean VOT $F_{(DF, DF\,den)}$	p	Mean CD $F_{(DF, DF\,den)}$	p
S__]$_\phi$	30	$F_{(1,26)} = 3{\cdot}81$	0·0618	$F_{(1,26)} = 141{\cdot}96$	<0·0001*
VV__]$_\phi$	25	$F_{(1,20)} = 0{\cdot}07$	0·7999	$F_{(1,20)} = 138{\cdot}61$	<0·0001*
V__]$_\phi$	12				
total	67				

Table V

Statistical results for data in Fig. 5.

and prosodic) immediately preceding or following the stop consonant in question. It is important to note at this point that the smallest difference between geminate and singleton is initially. This suggests that even

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though the difference is statistically significant, i.e. a length distinction is made between geminates and singletons, phrase-initially neutralisation might occur.

4.3.2.3 *Medial stops.* Taking the uncontroversial case first, the word-medial stops render the most clear-cut results. As Fig. 4a and Table IV show, medial stops display no crucial VOT duration differences in any of the environments. Although the VOTs tend to be shortest after S __ and longest after VV __ , the differences are not significant. The CD, however, is crucial (see Fig. 4b): geminates are roughly three times as long as singletons, the same result as in Dieth & Brunner (1943).

This discrimination in terms of duration for consonants in intersonorant position accords with phonological assumptions about geminate and singleton timing. A geminate can be accommodated without problems in precisely these environments: both consonantal slots can be associated with syllabic structure since one position is available in the rhyme and one in the onset (cf. (6)).[17]

Thus, word-medial stops are not a testing ground for the prediction of phonological length neutralisation. It is therefore crucial to see what happens to stops when they are placed in an environment where the timing distinction cannot be phonologically maintained, i.e. where either no onset or no coda position is available for the extra geminate slot (cf. (8b) and (10)). Such situations can occur word-finally and word-initially; we will consider these positions in turn.

4.3.2.4 *Final stops.* The acoustic measurements of word-final stops are divided into two parts, phrase-final and phrase-medial. In phrase-final position we expect the contrast to be maintained (cf. (7b)). Recall that these words were produced in isolation, so they had no context following.

In the postsonorant context of Fig. 5a we see for once a considerable difference in the realisation of geminate and singleton VOTs. The difference in the two environments, however, is statistically not significant.

The data in Fig. 5b show significant CD differences (see Table V) after a branching nucleus, i.e. after S __ or VV __ .[18] Phrase-final underlying geminates and singletons thus remain clearly distinguished in this position. This is possible, because, as a rule, final stops are audibly released and therefore the acoustic correlate of the phonological distinction (CD) has clear starting and end points.

Comparing now the absolute duration of phrase-final stops with the

[17] This is the standard assumption with respect to geminate syllabification. See e.g. Lehiste *et al.* (1973) for an account of geminates as ambisyllabic consonants.

[18] As is evident from the last column in Fig. 5, our data actually show no instances of a non-branching nucleus (V __) followed by a word-final singleton, because the words we chose for comparing word-final consonants were all monosyllabic, for reasons explained above. Due to the minimal word constraint mentioned in note 5, underlying /CVC/, e.g. *Rad* 'wheel' /ʀat/, always surfaces as [CVVC], unless it is part of a compound or affixed by an element that contributes an additional mora (e.g. the plural of /ʀat/ is [ʀɛtəʀ], not *[ʀɛɛtəʀ]). Nevertheless, the geminate–singleton opposition is not correlated with the length of the preceding vowel (see note 12), and thus the comparison here is valid.

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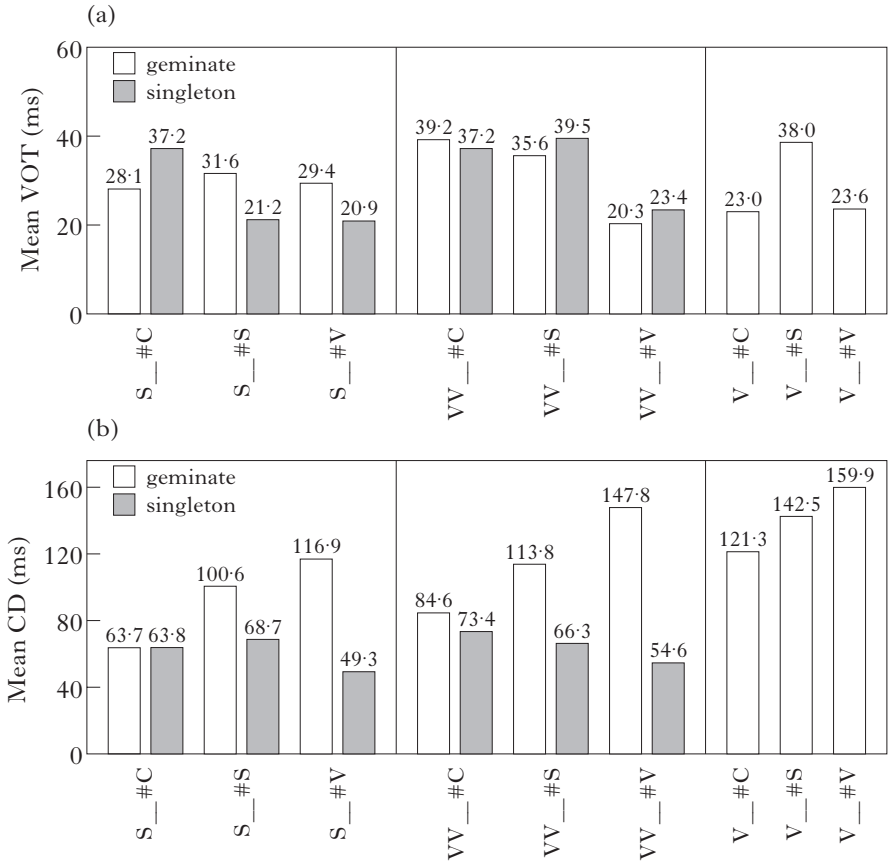


Figure 6

(a) Mean voice onset time in ms for word-final phrase-medial stops, distinguished by environment: S__ (e.g. *al*/tt/, *Wal*/t/), VV__ (e.g. *Ta*/tt/, *Ra*/t/) and V__ (e.g. *ne*/tt/), in the contexts __#C (/k/*saitt*), __#S (/l/*ernä*) and __#V (/aa/). The differences are not significant. (b) Mean closure duration in ms for word-final phrase-medial stops, distinguished by environment. The differences are significant for S__#S, S__V, VV__#S and VV__#V, but not for S__#C and VV__#C.

word-medial ones in Fig. 4, we see that VOTs *and* CDs of *both* geminates and singletons are longer phrase-finally. Prosodic lengthening of this sort is typical of phrase-final entities, which have been observed to receive more prominence in general (e.g. Shattuck-Hufnagel & Turk 1996).

When word-final stops appear within a phrase, as opposed to at a phrase boundary, the phonological timing of geminates and singletons should pattern in the same way as word-medial stops, provided that for underlying geminates two linking positions are available (see (8)).

As we have seen in all the previous data, the differences in VOT are not significant for phrase-medial final stops (see Fig. 6a and Table VI). Notice also that there is nothing consistent about which measure is longer.

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	number of items	Mean VOT $F_{(DF, DF\,den)}$	p	Mean CD $F_{(DF, DF\,den)}$	p
S__#C	36	$F_{(1,31)} = 2{\cdot}93$	0·0970	$F_{(1,32)} = 0{\cdot}06$	0·8050
S__#S	31	$F_{(1,27)} = 2{\cdot}34$	0·1377	$F_{(1,27)} = 12{\cdot}03$	0·0018*
S__#V	20	$F_{(1,16)} = 0{\cdot}95$	0·3442	$F_{(1,16)} = 46{\cdot}24$	<0·0001*
VV__#C	21	$F_{(1,16)} = 0{\cdot}04$	0·8446	$F_{(1,17)} = 1{\cdot}52$	0·2339
VV__#S	18	$F_{(1,13)} = 0{\cdot}11$	0·7407	$F_{(1,14)} = 42{\cdot}37$	<0·0001*
VV__#V	20	$F_{(1,15)} = 0{\cdot}03$	0·8685	$F_{(1,15)} = 364{\cdot}73$	<0·0001*
V__#C	15				
V__#S	11				
V__#V	8				
total	180				

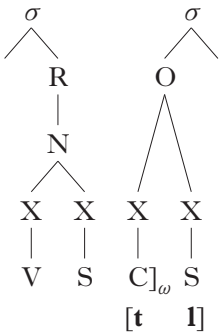
Table VI
Statistical results for data in Fig. 6.

Sometimes it is the VOT of geminates which is longer, sometimes that of singletons. Moreover, there is in fact an inverse pattern if the environments are considered: when the geminate VOT is longer in the S __ environment then the singleton measure is longer in the VV __ environment and *vice versa*. This variation is highly speaker-dependent. If VOT is to serve as a reliable correlate of the phonological distinction, then it ought to behave consistently. This is clearly not the case.

In contrast, differences in CD in the intersonorant contexts (S __ #S, S __ #V, VV __ #S and VV __ #V) are all highly significant and consistent (see Fig. 6b and Table VI). These results support our prediction in (5a), namely that all stop positions can be linked to prosodic structure in intersonorant context. The contexts S __ #S and VV __ #S are particularly interesting, because the syllabification results in onset clusters that do not occur at the beginning of lexical words, in our case [tl].

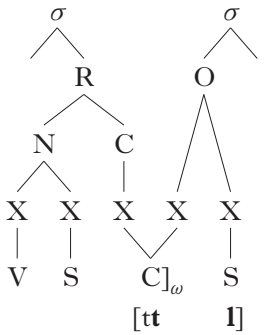
(13) *Word-final consonants followed by a sonorant-initial word*

/VSC#S/ → [VSCS]



e.g. *Wal*/t l/*ernä*

/VSC$_1$C$_1$#S/ → [VSC$_1$C$_1$S]



e.g. *al*/tt l/*ernä*

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Such onset clusters as depicted in (13), however, also occur word-medially, as for example in *bettle* [bɛt.tlə] 'to beg'. Thus, the phonotactic restrictions on word-medial and phrase-medial onset clusters in general are less strict than on word-initial clusters in lexical words.[19]

The phonetic fact that the CDs of word-final stops in the environment S __ #C and VV __ #C are not significantly different is interpreted as reflecting the deletion of the second timing slot of geminates (cf. (8b)). The removed length position cannot be phonetically interpreted, and as a consequence the geminate–singleton opposition is neutralised, both in terms of the phonological structure and the phonetic realisation.

Observe also in Fig. 6b that (a) geminates after short vowels are consistently longer than after branching nuclei and (b) geminates and singletons show an inverse pattern after long vowels: the former are longest if followed by vowels and shortest if followed by obstruents; the latter are longest if followed by obstruents and shortest if followed by vowels. It must be noted, however, that these are tendencies. The differences are not significant; moreover they are highly speaker-dependent.

To briefly summarise the main findings for word-final stops:

(i) Phrase-finally, the phonological distinction is kept: the second timing slot of geminates can be phonetically interpreted as length since the position is licensed at the phrase edge and the stop is audibly released (7).

(ii) Contrast neutralisation occurs phrase-internally, as predicted in (8b), after branching nuclei and before obstruent-initial words: unlinked timing slots of geminates are erased and receive no phonetic interpretation.

(iii) The quantity opposition is maintained phrase-internally in intersonorant context, as predicted in (6).

In addition, the absolute CD values of both geminates and singletons are considerably longer phrase-finally than phrase-medially.

4.3.2.5 *Initial stops*. Initial stops within a phrase pattern exactly like the final stops within a phrase, i.e. the geminate–singleton contrast is maintained in intersonorant environments, while it is neutralised when only one of two timing slots is prosodically linked (cf. (10)).

Figure 7a and Table VII show the now familiar picture that VOT is not distinctive. Although the difference in the C# __ V environment is fairly sizeable, it is not significant. Once again we see that VOT is quite inconsistent, being longer for geminates in certain environments and shorter in others.

With respect to the CD measurements in Fig. 7b, we find contrast neutralisation when the word-initial stop in question is preceded by an obstruent, as predicted in (10). The differences in postsonorant environments are distinctive, except for the V# __ V context. This last result seems very odd, for it is exactly the intervocalic environment in which length contrasts in general are maintained most robustly. However, this

[19] Whether all the possible stop–sonorant combinations – even those not occurring word-medially – are actually syllabifiable in a phrasal context is an interesting test case for the syllabification theory, but cannot be pursued here any further. For a discussion of lexically occurring onset clusters, see Kraehenmann (1996: 74–79).

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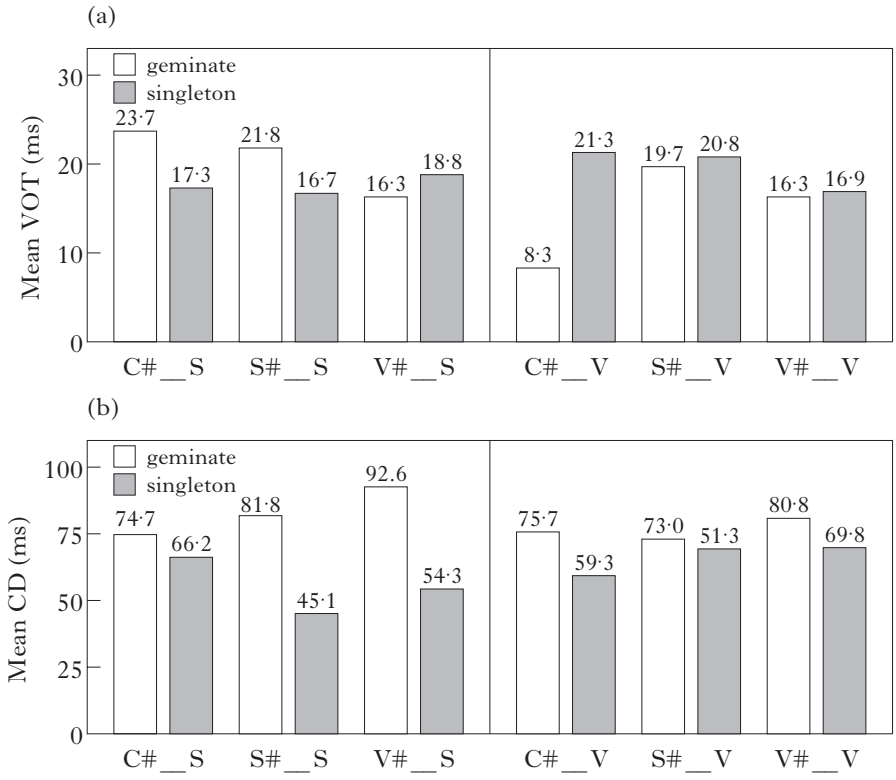


Figure 7

(a) Mean voice onset time in ms for word-initial phrase-medial stops, distinguished by environment: __S (e.g. /pp/*lunder* 'Danish pastry', /p/*retzel* 'pretzel') and __V (e.g. /pp/*omfrit*, /p/*ohne*). The differences are not significant. (b) Mean closure duration in ms for word-initial phrase-medial stops, distinguished by environment. The differences are significant for S#__S, V#__S and S#__V, but not for C# __ S, C# __V and V# __V.

	number of items	Mean VOT $F_{(DF, DF\,den)}$	p	Mean CD $F_{(DF, DF\,den)}$	p
C#__S	12	$F_{(1,\ 8)} = 0{\cdot}61$	0·4584	$F_{(1,\ 8)} = 0{\cdot}12$	0·7364
S#__S	44	$F_{(1,40)} = 3{\cdot}11$	0·0855	$F_{(1,40)} = 24{\cdot}47$	<0·0001*
V#__S	26	$F_{(1,22)} = 0{\cdot}17$	0·6877	$F_{(1,22)} = 35{\cdot}74$	<0·0001*
C#__V	6	$F_{(1,\ 3)} = 1{\cdot}43$	0·3177	$F_{(1,\ 3)} = 6{\cdot}22$	0·0882
S#__V	51	$F_{(1,47)} = 0{\cdot}14$	0·7145	$F_{(1,47)} = 6{\cdot}50$	0·0141*
V#__V	22	$F_{(1,19)} = 0{\cdot}01$	0·9093	$F_{(1,19)} = 0{\cdot}52$	0·4800
total	161				

Table VII

Statistical results for data in Fig. 7.

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puzzle finds an explanation if we consider what the speakers actually produced, as opposed to what our expectations were. The words in question are given in (14):

(14) *Test items for initial stop contrasts* (*environment* #__V)

expected	/pp/~/p/	/tt/~/t/	/kk/~/k/
geminate	Pomfrit	Turte	Kotlett
singleton	Bohne	Dotter	Gurke

The results of a perception test run on these items in postvocalic (V# __) and postsonorant (S# __) context show that the items *Bohne*, *Turte* and *Gurke* were heard to have been produced as expected in all the tokens, while the other three items behaved as shown in (15) (boldface indicates the values expected for the recordings).

(15) *Test items with initial consonants* (*production as perceived*)

	Pomfrit		Dotter		Kotlett	
	long	short	long	**short**	**long**	short
speaker 1	4	–	1 (S__)	3	4	–
speaker 2	–	4	3	–	–	4
speaker 3	4	–	4	–	–	4

Speaker 2 produced all items against our expectations and speaker 3 all but the four *Pomfrit* tokens, while speaker 1 conformed to our expectations, except for one *Dotter* item in the S __ environment. Although it appears that variation within words only occurs with speaker 1 and could be optionally conditioned by a preceding sonorant consonant, the data from words with initial stop–sonorant clusters, in which the same problem could have occurred, suggest that this cannot be the case. Here only one of the six test items shows such speaker-specific variation, namely *Draschee* 'coated tablet'.

(16) *Variation in test item* Draschee

	Draschee	
	long	**short**
speaker 1	4	–
speaker 2	–	4
speaker 3	2 (1 each)	2 (1 each)

Speaker 1 always produced this item as a geminate, whereas speaker 2 always did so as a singleton. Speaker 3, however, shows variation not only in the length contrast, but also within environments: he rendered one test item twice with geminates and twice with singletons, one each in the V# __ and S# __ context, respectively.

If these facts are considered are factored into the statistics, the differences in mean CD turn out to be significant within the environments. This can be seen in Fig. 8 and Table VIII.

Evidently, the speakers have different underlying representations of the

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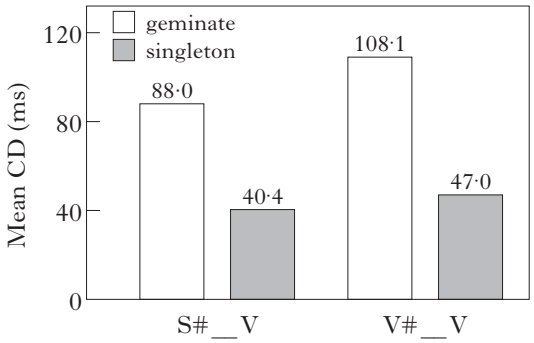


Figure 8

Mean closure duration in ms for word-initial phrase-medial stops, distinguished by environments S#__V (e.g. *vi*/l pp/*lunder*, *vi*/l p/*ohne*) and V#__V (e.g. *h*/a pp/*lunder*, *h*/a p/*ohne*). Categorisation geminate–singleton as perceived. The differences are significant.

	number of items	Mean CD $F_{(DF, DF\,den)}$	p
S#__V	51	$F_{(1,47)} = 92{\cdot}86$	$<0{\cdot}0001$*
V#__V	22	$F_{(1,19)} = 113{\cdot}14$	$<0{\cdot}0001$*
total	73		

Table VIII

Statistical results for data in Fig. 8.

initial stops in these words. The speaker variation is reflected for both geminate and singleton stop-initial words. One reason for this variation could be the considerable surface ambiguity that occurs across word boundaries. The ambiguity comes from accidental co-occurrence of identical consonants, as well as assimilations, as shown in (17).

(17) a. I han /ə **k**/urke gsee — [i han ə **k**uʀk^{x}ə ksee]
'I have seen a cucumber'

b. I ha /**tt k**/urke gsee — [i ha **kk**uʀk^{x}ə ksee]
'I have seen the cucumber'

c. au /**k**/ern — [au **k**əʀn]
'gladly, too'

d. nö/**t k**/ern — [nö **kk**əʀn]
'not gladly'

e. I han /ə **kk**/utsche gsee — [i han ə **kk**utʃə ksee]
'I have seen a coach'

f. I ha /**tt kk**/utsche gsee — [i ha **kk**utʃə ksee]
'I have seen the coach'

g. au /**kk**/nau — [au **kk**nau]
'exactly, too'

h. nö/**t kk**/nau — [nö **kk**nau]
'not exactly'

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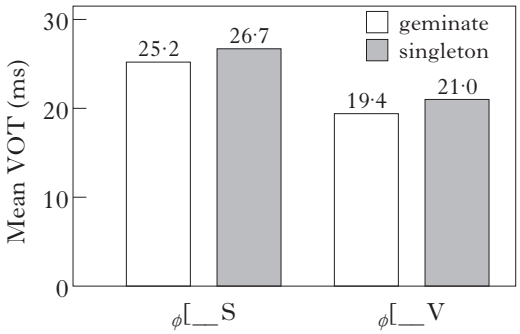


Figure 9

Mean voice onset time in ms for word-initial phrase-initial stops, distinguished by environments as in Fig. 8. The differences are not significant.

	number of items	Mean VOT $F_{(DF, DF\ den)}$	p
ϕ[__S	37		
ϕ[__V	36	$F_{(1, 33)} = 0{\cdot}07$	0·7976
total	73	$F_{(1, 32)} = 0{\cdot}41$	0·5257

Table IX

Statistical results for data in Fig. 9.

The feminine singular determiner {tt} and the word-final /t/ of 'not' have the same effect on both word-initial /k/ and /kk/, namely the sequence is realised as [kk]. Such contact geminates routinely occur when stops meet across word boundaries. The result is that there is ambiguity as to whether a stop-initial word starts with an underlying geminate or a singleton, *even though* the stop surfaces in an intervocalic environment. The information is opaque enough that listeners may have difficulties in deciding whether the surface consonants stem from an underlying geminate or singleton. We return to the issue of speaker variation in the underlying representation of word-initial stops in §5.

While initial and final stops within phrases seem to have a lot in common in terms of their phonological and phonetic patterns, initial stops at a phonological phrase boundary differ from final ones. Although the phonological structure is similar (cf. (9) and (7b)), the acoustic situation of initial stops is clearly different: there is no measurable CD, because the silence before the release does not have any starting point. As a result, the phonetic correlate of the distinction is not realisable.

The VOT data given in Fig. 9 and Table IX confirm what has been found for medial and final stops, namely that the VOT measures are no help in identifying the underlying length distinction: the differences are far too small. Thus, in the absence of the primary correlate, only secondary acoustic features such as the ones found by Abramson (1991,

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1999) or Fulop (1994) conceivably could make the distinction still recoverable. However, evidence against secondary correlates taking over when CD is absent in Swiss German comes from a perception study we conducted and briefly discuss next.

In a decision task six native speakers of Swiss German evaluated the initial stop–vowel sequence of 28 real words. These sequences contained the full computer-edited consonant length (CD plus VOT) taken from an intersonorant context plus a 50 ms window of the following vowel. Every token was presented after an attention beep and was repeated twice in 1·5 sec intervals. In a forced choice task, the listeners then had to make a check mark beside the consonant sound they thought they had heard. They had two choices. In only 54% of the cases did they report hearing a long consonant when the test item actually contained a geminate. The numbers for the singletons are slightly better, with a hit rate of 67%. Thus, in absolute phrase-initial position, the possibility of recovering the underlying length distinction is only slightly above chance level. If there really are any stable secondary acoustic correlates, they do not seem to be strong enough to uphold the phonological distinction when the length cue is missing. In this respect, Swiss German differs from Pattani Malay, for which it has been claimed that native speakers can perceive the difference in phrase-initial voiceless geminates (Abramson 1991, 1999).

The crucial difference between stops at phrase edges lies not in the phonology but in the phonetic realisation: for initial stops the length cannot be interpreted because there is no decisive starting point of the closure; for final stops it is possible to realise the closure duration with the release of the consonant.[20]

4.3.3 *Summary*. The Swiss German data presented can be summarised as follows.

As has been reported for other Swiss German dialects (Brunner 1953, Enstrom & Spörri-Bütler 1981, Fulop 1994, Ham 1997, 1998), voice onset time is not distinctive in Thurgovian (see Lahiri & Hankamer 1988, Cohn *et al*. 1999 for similar conclusions in other languages). In most of the cases the mean measures are virtually identical for geminates and singletons. Positional differences in duration for one consonant type are by and large matched by the other.

The measure of the closure duration, however, is a reliable and consistent correlate of the underlying distinction between geminate and singleton stops.

[20] Carlos Gussenhoven (personal communication) made the suggestion that it seems that the initial contrast would not have come about without there being a phonetic cue in final position at the phrase edge. As interesting as this thought is, we have reservations that this is a possible state of affairs. Taken to the extreme, it can mean that the existence of initial geminates is conditional on the existence of final geminates, a claim which we believe would be very difficult to substantiate. In addition, in light of language acquisition, phrase edges are rather untypical locations for learning stem-final contrasts. Phrase-medial contexts, where stem alternations (paradigmatic and across words), are possible are more likely and more promising candidates for this.

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Phrase-medially, whenever the two geminate slots can be prosodically licensed the closure durations of geminates are significantly longer than the ones of singletons. This is the case in intersonorant contexts throughout (see Figs. 4b, 6b, 7b and 8).

Where the context is not intersonorant, there is an asymmetry in how initial and final geminate stops are phonetically realised. (i) First, within a phonological phrase, neutralisation due to Stray Erasure and concomitant shortened closure duration occurs with final geminates if the preceding nucleus is branching and the following words starts in an obstruent (see Fig. 6b). With initial geminates this occurs if the preceding word ends in an obstruent, regardless of the branchingness of the nucleus (see Fig. 7b). (ii) Second, at the edge of a phonological phrase, no *structural* (i.e. phonological) neutralisation occurs since the unsyllabifiable geminate slots are licensed at the level of the phonological word and thus tolerated at the domain boundary. Word-finally, such positions can be phonetically interpreted since the stop closure has discernible starting and end points – the offset of the preceding sound and the audible release, respectively. As a consequence, geminates and singletons remain distinguished by their closure duration (see Fig. 5b). Word-initially, however, the phonetic situation is different: there is no audible starting point for the stop closure since it is a period of silence, which means the underlying distinction cannot be realised. As the perception data confirm, this results in geminates and singletons becoming indistinguishable. Whether this can be called neutralisation is an interesting and debatable issue. On the one hand, closure duration is not there to be evaluated at all. On the other hand, the phonological contrast cannot be realised, as in the clear neutralisation cases phrase-medially where closure durations become identical.

In contrast to some other languages with initial voiceless geminates which seem to make use of secondary cues to recover the quantity distinction when the main correlate is missing, Swiss German only relies on the closure duration. If this correlate is absent, the contrast is not recoverable.

5 Where does the geminate–singleton contrast come from?

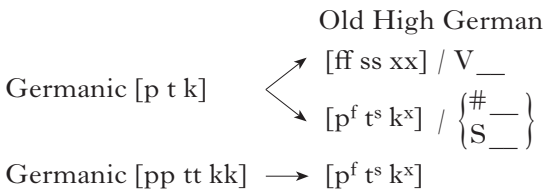
The quantity distinction which pervades the consonant system in Swiss German today arose historically from a geminate–singleton opposition in word-medial and word-final position. Kraehenmann & Lahiri (1999) argue that contemporary Swiss German dialects show distinctive length in all word positions due to the incorporation of loanwords into the language system after the Old High German Consonant Shift.

The Old High German Consonant Shift, sketched in (18), had a crucial effect on the oldest stages of German: no voiceless stops survived, as they all mutated either to geminate fricatives or to affricates.[21]

[21] Note that Germanic [pp tt kk] were always medial or final, never initial.

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(18) *Effects of the Old High German Consonant Shift on voiceless stops*



The voiced stops were not affected by this shift. In Old Alemannic, the precursor to the Swiss German dialects, however, voicing gradually lost its significance within the obstruents altogether, because there was no longer any opposition: no voiceless singletons remained and most of the voiced geminates became voiceless, as in the standard Old High German system.[22] In addition, West Germanic Gemination reintroduced medial and final geminates, such that, at a particular stage, the distribution of the non-fricative Old Alemannic obstruents was the following:

(19) *Distribution of Old Allemanic non-fricative phonemes*

initial			*medial*			*final*		
p	t	k	p	t	k	p	t	k
			pp	tt	kk	pp	tt	kk
p^f	t^s	k^x	p^f	t^s	k^x	p^f	t^s	k^x

Singleton stops and affricates occurred in all word positions, geminates medially and finally only, leaving a systemic gap initially.

Loanwords that entered the language at this stage from Romance and other languages posed a problem when they contained a stop whose voicing specification was contrastive in the original language. Swiss German speakers had at their disposal a contrast between geminate and singleton in all but word-initial position. The opposition in medial stops, such as *Kabel* 'cable' and *Stapel* 'pile', was translated into the singleton–geminate distinction as [k^xapəl] and [ʃtappəl], but initial stops, as in *Ballast* 'burden' and *Palast* 'palace', were more of a challenge. Swiss German speakers had three options: (a) to borrow all of them as singleton [p], (b) to reintroduce a contrast [b ~ p] or (c) to use an existing contrast, but to extend it to initial position, *viz* [pp]. (c) was adopted, as shown by *Ballast* /palaʃt/ *vs*. *Palast* /ppalaʃt/. Obviously, for the speakers, the contrast between [b] and [p] was discernible, otherwise (a) would have been a viable option. But what is crucial is that although introducing a geminate [pp] in word-initial position was highly marked from the perspective of

[22] Other independent changes occurred, such as for example Germanic *d/*dd to [t]/[tt]. They are left out of the discussion because they are irrelevant to the issues at hand.

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universal markedness, this step was preferable to initiating a new contrast. To 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. Had there only been borrowings with voicing contrast medially, then in all probability no change in the system would have occurred. It was the words with initial (and final) opposition which were more noticeable, and therefore these are a source of extra interest.

As a result, contemporary Swiss German systems are as follows (examples from Thurgovian):

(20) a. *Original voiced stops are phonologically voiceless*

/**p**oonə/	'bean'	/ʃtu**p**ə/	'living room'	/kʀa**p**/	'grave'
/**tt**ak/	'day'	/va**t**ə/	'thy'	/ra**t**/	'wheel'
/**k**ʀap/	'grave'	/po**k**ə/	'bow'	/tta**k**/	'day'

b. *Voiced stops in loanwords are phonologically voiceless singletons*

/**p**oott/	'boat'	/pi**p**lə/	'bible'	/sno**p**/	'snob'
/**t**attlə/	'date'	/ʀa**t**aʀ/	'radar'	/faa**t**/	'tasteless'
/**k**alopp/	'gallop'	/tɛ**k**ə/	'sword'	/soo**k**/	'suction'

c. *Voiceless stops in loanwords are phonologically voiceless geminates*

/**pp**aaʀ/	'pair'	/xa**pp**ə/	'cap'	/kalo**pp**/	'gallop'
/**tt**uʀttə/	'layer cake'	/ma**tt**ə/	'mat'	/fɛ**tt**/	'fat'
/**kk**omfi/	'confiture'	/ja**kk**ə/	'jacket'	/paŋ**kk**/	'bank'

In summary, Swiss German speakers incorporated loans into the existing system of contrast. Borrowings with initial stops based on a voicing distinction caused the extension of the geminate–singleton opposition to word-initial position. They did this in spite of the fact that the main acoustic correlate of consonant length, namely closure duration, is absent when not in a phrasal context.

Finally, recall that in §4.3.2.5 we mentioned speaker variability with respect to the underlying representation of initial stops. In addition to the syntactically conditioned variability there is also a historically based source. While word-initial *geminate* stops must all come from loans, word-initial *singleton* stops can have two origins: either Proto-Germanic voiced aspirates via Grimm's Law or from loans. The loans had to be fitted into the existing system. It may well be that for speakers the decision whether these initial sounds should be classified as geminates or singletons was and is not always straightforward. This might explain some of the variation across speakers and speech communities in adapted words. By implication we would not expect any variation of this sort with Germanic roots that have been in the system since before the Old High German developments. Our data seem to support this expectation: the word *Bohne* 'bean' (Gmc. **baunō*),[23] which consistently has an initial singleton, is definitely not a loanword. On the other hand, it must also be possible for loans not to show variation, as the example *Gurke* 'cucumber' (cf. Polish *ogurek*) illustrates.

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6 Conclusion

The results of the synchronic data summarised in §4.3.3 and the historical developments mentioned in §5 taken together are testimony to a rather unusual system. The quantity contrast in word-initial position was created on the basis of the existing system of phonological contrasts, in spite of the fact that the acoustic correlate of the distinction is not always phonetically realisable, nor perceptible for that matter.

Whether the measure of closure duration is used solely as a *perceptual* cue to recover the underlying quantity distinction remains to be shown. However, the neatly patterning measurement results presented here suggest that this is very likely the case.

Finally, we have been able to show with the acoustic data of Thurgovian that there are two types of contrast 'cancellation'. One is clear neutralisation, where phonology and phonetics go hand in hand: the deletion of phonological structure (Stray Erasure of a timing position) is reflected in shorter duration. The other is not so straightforward, and only involves the contrast in initial position at a phrase edge. Phonologically the distinction can be maintained: singletons are singly linked, geminates doubly. Phonetically, though, it is not possible to realise the length correlate: the closure duration of voiceless stops is a period of silence and requires a discernible starting point as reference which is simply not available phrase-initially. Thus the nature of the phonetic cue itself is at issue. Surely, this fact is part of the reason why initial geminates are so rare.

Appendix A: sample test items used in the experiment

(21) *Medial stops*

a. *intervocalic*

	V̄__V	V̆__V		V̄__V	V̆__V
pp	huupä	Suppe	p	Huube	Stube
tt	riitä	bittä	t	Chriide	Wide
kk	Hoogge	Rogge	k	ploogä	Boge

b. *intersonorant*

	S__V		S__V
pp	Lampe	p	Bombe
tt	Kante	t	Rande
kk	Tolgge	k	folgä

[23] All etymologies have been verified in Kluge (1999).

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(22) *Final stops*

a. *postvocalic*

	V̄__	V̆__		V̄__	V̆__
pp		schlapp	p	Raab	—
tt	Tat	nett	t	Rad	
kk		dick	k	Zwiig	

b. *postsonorant*

	S__		S__
pp	Lump	p	Chalb
tt	alt	t	Wald
kk	chrank	k	arg

(23) *Initial stops*

a. *prevocalic*

	__V		__V
pp	Pomfrit	p	Bohne
tt	Turte	t	Dotter
kk	Kotlett	k	Gurke

b. *presonorant*

	__S		__S
pp	Plunder	p	Bretzel
tt	Trube	t	Draschee
kk	Gnagi	k	Glacee

Appendix B: question and answer sentences used in the experiment

word-final stops

environment: __#V

A	*on screen*	Wie fangt de Abschnitt aa?	'How does this paragraph start?'
B	*on screen*	Tat	'deed'
C	*answer*	De fangt mit Tat aa.	'It starts with deed.'

environment: __#S

A	*on screen*	Weles Wort wöt er lernä?	'Which word does he want to learn?'
B	*on screen*	alt	'old'
C	*answer*	Er wöt s Wort alt lernä.	'He wants to learn the word old.'

environment: __#C

A	*on screen*	Was hät die Frau gsait?	'What did this woman say?'
B	*on screen*	Rad	'wheel'
C	*answer*	Si hät Rad gsait.	'She said wheel.'

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word-initial stops

environment: V#__

A	*on screen*	Häsch das gern?	'Do you like this?'
B	*on screen*	Kotlett	'cutlet'
C	*answer*	I ha Kotlett nöd gern.	'I don't like cutlet.'

environment: S#__

A	*on screen*	Wievil chash vo dem essä?	'How much can you eat of this?'
B	*on screen*	Glacee	'ice cream'
C	*answer*	I cha vil Glacee essä.	'I can eat a lot of ice cream.'

environment: C#__

A	*on screen*	Dörfsch das essä?	'Are you allowed to eat this?'
B	*on screen*	Gurke	'cucumber'
C	*answer*	I dörf nu wenig Gurke essä.	'I'm only allowed to eat a little cucumber.'

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