Comparing voiced and voiceless geminates in Sienese Italian: what role does preaspiration play?

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Abstract

This paper compares the acoustic phonetic appearance of voiced & voiceless geminate stops in Sienese Italian. In our spontaneous speech data voiceless geminate stops are frequently preaspirated, which is an extremely rare phenomenon cross-linguistically. Preaspiration of voiceless stops has been associated in other languages with devoicing of voiced stops. We compare the acoustic appearance & duration of voiceless /VC:/ sequences (with & without preaspiration) with voiced /VC:/ sequences in our language. Results indicate that long voiced stops in Sienese Italian are often partially devoiced – a phenomenon that has not been reported previously for any variety of Italian. We suggest that preaspiration & devoicing are likely related, & attempt to provide an articulatory explanation as to why they occur.

1. Introduction

In this paper we compare the acoustic appearance of phonologically voiced & voiceless geminate stops in Sienese Italian. Previously, we have uncovered unexpected variability in the articulation of long voiceless stops in this variety of Italian (see eg. Stevens 2004; Stevens & Hajek 2004), whereby they show frequent preaspiration & other glottal effects. Here we compare voiced & voiceless long stops in Sienese Italian in order to determine whether voiced stops are subject to some kind of articulatory shift that might parallel preaspiration. We are led to this investigation by a correlation previously observed in many varieties of Scandinavian languages between preaspiration in voiceless stops & (partial) devoicing of voiced stops (eg. Hansson 2001:165). This correlation is well known in Icelandic, eg. /vidd/ [vitt] 'wide' v. /vitt/ [viht] 'breadth' (Ladefoged & Maddieson 1996:71), but has not been reported outside Scandinavia.

2. Background

2.1. Geminates in Italian

Italian is well-known for the presence of a long v. short consonant contrast, eg. /kanne/ 'canes' v. /kane/ 'dog'. Both voiceless & voiced stops may appear as short or long, e.g. /papa/ 'pope' v. /pappa/ 'mush' & /abako/ 'abacus' v. /babbo/ 'dad'. Stressed vowels are predictably short preceding geminate consonants & in other closed syllables, but are fully long in open syllables i.e. ['fat.to] v. ['fa:.to]. As a result, stressed rhymes are always phonologically heavy or bimoraic.

2.2. Preaspiration

Preaspiration is a very rare phenomenon across the world's languages, occurring most often in Scandinavia but elsewhere in a handful of languages elsewhere (see Helgason 2002 for detailed discussion & references). Preaspirated stops occur when the articulatory timing is such that the glottis widens before supralaryngeal closure, resulting in a period of voiceless glottal frication. This frication is visible on spectrographic displays in the higher frequencies, & is often preceded by a region of breathy voice. Hansson (2001:161) provides clear evidence in a cross-linguistic survey that preaspiration occurs most frequently in the context of long voiceless stops /pp tt kk/.

With respect to previously published experimental research on Italian, only Gobl & Ní Chasaide (1999) report any kind of non-modal offset in vowels before medial voiceless stops. In a study of 4 speakers, they found evidence of breathy voice as a result of early glottal abduction. The presence of preaspiration in Italian has, however, been briefly noted by Payne (1996) in an unpublished study. She found evidence for it in the controlled laboratory speech of two out of her sample of six Central Italian speakers (one each from Tuscany & Rome). To the best of our knowledge

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preaspiration has not been noted for any other area of the Romance-speaking world.

2.3. Voiced geminate stops across languages

Relatively few languages are reported to have voiced geminate stops, compared with their voiceless counterparts (see e.g. Hayes & Steriade 2004). This disparity is often attributed to the extra articulatory effort required to maintain full vocal fold vibration throughout the supralaryngeal closure (Ohala 1983; Podesva 2000; Payne 2000:95 for Italian). As a result, passive devoicing can occur, and what was or is phonologically a voiced stop may be realized phonetically as a voiceless unaspirated stop, e.g. Nobiin Nubian [sɛgɛd] 'scorpion' v. [sɛgɛttɔn] 'and scorpion'. Diachronic evidence also suggests that voiced geminates often become fully voiceless over time, e.g. earlier /zabben/ is now /zappen/ 'sold' in Lebanese Neo-Syrian (Ohala 1983). However, there are also strategies available to speakers to maintain voicing throughout closure, eg. larynx lowering (see Ladefoged & Maddieson 1996:50-52), & acoustic evidence of uninterrupted voicing during long voiced closure exists for several languages (e.g. Cohn et al. 1999 for three Indonesian languages).

2.4. Voiced geminate stops in Italian and Italy

There is little evidence that voiced geminate stops in Italy have been subject to any cross-linguistic tendency in favour of devoicing. Indeed, short voiced stops may be subject to spontaneous gemination (with voicing fully maintained) in large parts of Central & Southern Italy, eg. Roman Italian /possibbile/, /abbile/, Southern Italian /bbello/ & /ddantsa/ alongside Standard Italian /possibile/ 'possible', /abile/ 'able' & /bello/ 'nice' & /dantsa/ 'dance' respectively (Rohlfs 1966). These data suggest that at least for Central & Southern varieties of Italian, we would not expect voiced stops to become voiceless over time, in contrast to what has occurred in Scandinavia & elsewhere.

Unfortunately, such a hypothesis is difficult to assess from a phonetic perspective, as acoustic analysis of voicing in Italian voiced geminate stops is hitherto lacking. The few existing experimental studies on stop voicing in Italian have focussed on singletons. Esposito (2002:220) reports that glottal pulsing is always present in short voiced stops. Most other studies examine only voiceless stops (e.g. Esposito & Di Benedetto 1999; McCrary 2004), or collapse short voiced & voiceless tokens together (e.g. Cerrato & Falcone 1998).

2.5. Are voiced geminate stops in Sienese Italian different?

Notwithstanding the general stability over time of voiced geminates in Central and Southern Italy, it is possible that phonologically geminate voiced stops specifically in Sienese Italian are different to those found in other dialects. They might be subject to (partial) devoicing by speakers, given that preaspiration occurs frequently in Sienese in the corresponding voiceless geminates, i.e. /bb/ > [bp] or [pp] could occur alongside /pp/ > [hp]. In other words, given the presence of preaspiration, the phonetic contrast between long voiceless & voiced stops might no longer involve the presence or absence of voicing throughout closure, but rather the relative timing or alignment of glottal & supralaryngeal gestures in Sienese. While in preaspirated stops glottal abduction occurs before supralaryngeal closure, in long voiced stops voicing would cease before release.

3. Methods

3.1. The data

The data are taken from a corpus of spontaneous speech recorded in Siena, Tuscany in Central Italy. Sienese Italian is very close to Standard Italian, & differs primarily in the presence of intervocalic spirantization (see below). Six speaker subjects (3m & 3f) are used in the present study. All spoke on a subject of their choice for around 10 minutes. We examined all examples of word-medial /pp tt kk bb dd gg/ that occurred in the spontaneous data, in total 255 tokens across 6 speakers. We could not compare the WM geminates with their singleton counterparts, as these are typically spirantized eg. /p t k/ > /φ θ h/ in intervocalic position, seen in /la pa'tata/ > [la φa'θaθa] 'the potato'. In our sample of 255 geminate tokens, 224 are voiceless, and only 31 are voiced. This distribution is consistent with existing reports of the low frequency of voiced geminates in Italian (Tonelli, Panzeri & Fabbro 1998:505; see also Payne 2000:95).

3.2. Methodology

For both voiced & voiceless /VC:/ sequences we measured the duration of the geminate consonant & the duration of the preceding vowel, using the Praat program. We later conducted statistical analysis (ANOVA) where appropriate. Results are presented for all six subjects combined, unless otherwise specified. General observations are made first in §4.1, before detailed presentation of results.

3.2.1. Voiceless /VC:/ sequences

The durations of the vowel, consonant closure, release burst & *post*aspiration were recorded. In addition, for voiceless /VC:/ sequences that showed *pre*aspiration or related glottal effects before consonant closure, the duration of this period was also measured, taken from the offset of modal voicing to the onset of consonant closure (see Stevens 2004 for more detail).

3.2.2. Voiced /VC:/ sequences

We also measured the duration of the vowel, consonant closure & release portions in voiced sequences. The duration of voicing in the closure period was also noted. This was taken as the offset of voicing, seen in the waveform & pitch trace, and as the loss of the voice bar on the spectrogram.

4. Results

4.1. Voiced vs. voiceless /VC:/

We first compared vowel, total consonant and total /VC:/ sequence durations for all voiced and voiceless tokens in the speech data:

Table 1. Average durations for voiced & voiceless /VC:/ sequences in the data, & total no. tokens. C includes closure & burst durations, & +/- preaspirated voiceless tokens are combined.

	/V/	/C:/	/VC:/	*No.*
Voiced	77	97	174	31
Voiceless	78	131	209	224

Vowels are not found to be longer before voiced consonants. This result is interesting given that across languages vowels are usually reported to be of greater duration before voiced than voiceless consonants, an observation for which perceptual, articulatory & timing reasons have been offered (eg. Maddieson 1997:624-626). Our results may reflect the impact of other factors such as relative position of lexical stress. These have not been controlled for at this stage, but merit further investigation at a later date.

Voiceless geminate stops are substantially longer than their voiced counterparts in our sample. Single factor ANOVAs comparing consonant durations for voiced & voiceless sequences showed these differences to be highly significant ($p = < 0.001$). This was also the case across different consonant places of articulation: /pp/ v. /bb/ & /tt/ v. /dd/ $p < 0.001$; /kk/ v. /gg/ $p = 0.008$.

4.2. Voiceless /VC:/

4.2.1. Acoustic appearance

Voiceless geminate consonants show a great deal of acoustic variation in Sienese Italian, although it is possible to broadly categorize tokens in the data into two main types: normal & preaspirated. An example of a normal /VC:/ sequence is in Figure 1, in which a clear transition from vowel to consonant is seen:

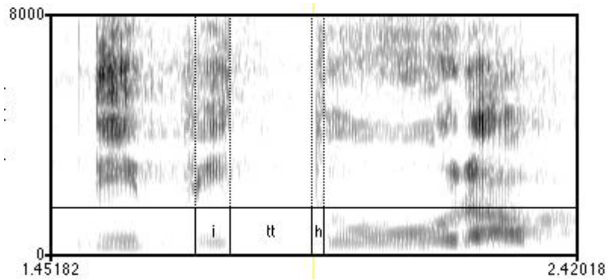

Figure 1. *A 'normal' voiceless /VC:/ sequence in the word* pittura *'painting' from speaker 5's spontaneous speech (s5:line 124).*

The second type of voiceless /VC:/ sequence includes tokens where preaspiration (but sometimes also breathy voice & occasional creak) preceded consonant closure. Figure 2 is an example of the same word produced by the same speaker as in Figure 1, but in this case the /tt/ is preaspirated & marked as [ht]:

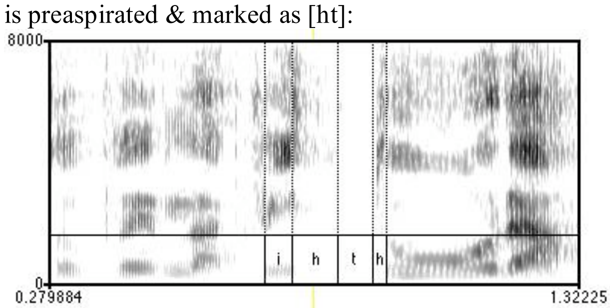

Figure 2. *Preaspiration, labelled as [h], in* pittura *'painting' (s5: line 89), visible on the spectrogram in the F3/F4 region preceding consonant closure.*

All 224 voiceless /VC:/ tokens were divided up according to whether preaspiration (or the other less frequent glottal phenomena) occurred preceding consonant closure. Table 2 shows the number of preaspirated tokens for each place of articulation:

Table 2. No. (& percent) of preaspirated tokens out of the total number of tokens, by place of articulation.

	/pp/	/tt/	/kk/	Overall
+pre	8/28 (28.6%)	81/170 (47.6%)	19/26 (73.1%)	108/224 (48%)

Results in Table 2 show that preaspiration occurs at all three places of articulation, although its frequency is affected by consonant place of articulation. It occurs in the following declining order of frequency: velar > dental > bilabial. Preaspiration occurs for all speakers, & overall nearly half (48%) of the voiceless geminate stops in the data are preaspirated. In Table 3 we list the average duration values according to place of articulation, for voiceless /VC:/ sequences with & without preaspiration:

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Table 3. Duration (in ms.) for voiceless /VC:/ sequences, by place of articulation & whether preaspiration occurs (+/-pre). Column F shows the actual no. of tokens.

	A	B	C	D	E	F
	V	*Pre*	*Clo*	*Rel*	*A+B+C+D*	*No.*
/pp/+pre	59	48	73	29	209	8
/pp/-pre	76	-	104	26	206	20
/tt/+pre	73	54	63	24	214	81
/tt/-pre	84	-	95	26	205	89
/kk/+pre	78	41	47	50	216	19
/kk/-pre	91	-	81	38	210	7
Total +pre	70	48	61	34	213	108
Total -pre	84	-	93	30	207	116

We can see from Table 3 that the presence of preaspiration in /VC:/ sequences affects both consonant & vowel durations (Columns A & C). Preaspiration is of segment-like duration (48ms.) and is associated with a statistically significant reduction in stop-closure duration (93ms > 61ms.), such that [hC] can be seen to alternate with [C:]. The drop in vowel duration, on the other hand, was not statistically significant. Overall rhyme duration hardly changes between +/- preaspirated sequences, or across different consonant places of articulation. The acoustic appearance of voiceless geminates in this variety is discussed in more detail elsewhere (Stevens 2004; Stevens & Hajek 2004).

4.3. Voiced /VC:/

Not surprisingly, preaspiration never occurs preceding voiced geminates. The waveform display in Figure 2 shows a bilabial voiced geminate stop in speaker 6's speech (male):[1]

4.3.1. Acoustic appearance

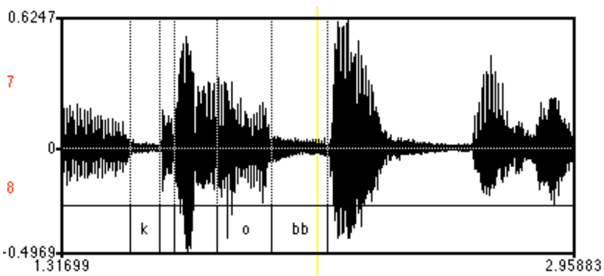

Figure 3. *Waveform display of a voiced /VC:/ sequence, in the word* conobbe *'s/he knew'.*

We can see in Figure 3, above, that the voiced bilabial geminate is both phonetically long, and fully voiced. In particular, comparison with the voiceless stop [k] in the same waveform clearly shows that voicing continues throughout closure in [bb]. Table 4, below, shows duration measurements (in ms.) for the 31 voiced geminates that occurred in the data, by consonant place of articulation:

Table 4. Duration (in ms.) for voiced /VC:/ sequences, for each place of articulation. St. dev. in brackets. Columns are named A-F for comparison with the corresponding measurements in Table 3.

	A	C	D	E	F
	V	*Clos*	*Rel*	*A+C+D*	*No.*
/bb/	76(33)	89(26)	9 (8)	174 (52)	24
/dd/	86(21)	74(10)	20(5)	180 (30)	6
/gg/	64	50	19	133	1

Long voiced bilabial tokens occur most often in the data, while there was only one occurrence of /gg/ in the pooled data. The uneven distribution across place of articulation is in line with existing studies of phoneme frequency in Italian. In particular, Tonelli et al. (1998) found no occurrence of /gg/ in their corpus of 12187 phonemes for Italian. We then measured the point at which voicing ceased, if at all, in the closure period for each voiced stop. Tokens were then divided up according to whether voicing was visible throughout the closure period. Table 5 below shows the frequency of fully voiced and partially devoiced tokens:

Table 5. Number of voiced tokens in the data that are fully voiced, & partially devoiced, according to C place of articulation.

	/bb/	/dd/	/gg/	total
Fully voiced	18	3	0	21/31 (68%)
Partially devoiced	6	3	1	10/31 (32%)
Total	24	6	1	31

While most of the voiced geminates (68%) are fully voiced in the data, partial devoicing is not infrequent (32%). This is especially so for the dental stop, for which half the tokens examined show some devoicing in the closure period. Although we have too few tokens of /gg/ to generalize, the overall pattern of reduced frequency of devoicing at bilabial place is consistent with earlier observations by Ohala (1983) and Hayes & Steriade (2004). They note that the aerodynamics of voicing in stops is directly affected by the degree of passive oral cavity expansion that can occur behind the point of oral closure: bilabial voicing is favoured because the softer tissue of the lips and tongue in the larger oral cavity in bilabials allows for a longer period of post-occlusion expansion. As airflow continues to pass through the glottis, voicing can continue.

[1] Both voiced and voiceless geminates were acoustically examined using spectrogram and waveform displays. Here the waveform clearly shows the phonation audible right through the closure period.

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In order to better understand the devoicing in our Sienese data, we also examined overall duration measurements & onset of devoicing at each place of articulation. Table 6 below shows the closure durations & devoicing onsets in milliseconds for voiced geminates at each place of articulation. Percentages indicate the amount of the closure duration that was fully voiced. Given that we have only one token of /gg/, it is excluded from further discussion.

Table 6. Av. closure duration (ms.) for fully voiced & partially devoiced tokens (St. Dev. in brackets). Percent fully voiced closure in italics. Final row shows av. onset of devoicing (ms.) for partially devoiced tokens.

	/bb/	/dd/	/gg/
Fully voiced *% Voiced*	91 (28) *100%*	82 (2) *100%*	- -
Part. devoiced *% Voiced*	82 (2) *48%*	67 (10) *86%*	50 *78%*
Onset of devoicing	40 (40)	58 (10)	39

Analysed in this fashion, our results do not correlate well with previous cross-linguistic & phonetic generalizations. In the first instance, it is predicted that as closure duration increases, so will the likelihood of devoicing, since it should become more difficult for airflow through the glottis into the cavity (& hence voicing) to be maintained. Instead, our results show the opposite effect: at both bilabial & dental place of articulation, fully voiced stops are longer than their devoiced counterparts. In the second instance, it is expected that the onset of devoicing will occur later in bilabials, since it is at this place of articulation that voicing is considered easiest to maintain. Such an outcome is supported, as Ohala (1983) and Hayes & Steriade (2004) note, by the results of an experiment to test the effect of place on the timing of passive devoicing: devoicing occurred at 82 ms. after bilabial closure, 63 ms. after coronal closure & 52 ms. after velar closure. Yet statistical analysis of our data did not find place of articulation to have a significant effect ($p = 0.152$, $F = 2.58$). It is not clear how we can account for this unexpected outcome in Sienese. We are also unable to explain the high degree of variation in bilabial devoicing (seen in the elevated standard deviation value): indeed 2 of 6 tokens were fully devoiced. Further investigation is clearly needed on both of these points.

5. Final Discussion & Conclusion

Our investigation of long voiceless & voiced stops in Sienese Italian confirms that both categories are subject to acoustic variability, albeit of different kinds. The former are often preaspirated (48%), while the latter are subject to frequent partial devoicing (34%). Our initial hypothesis that the presence of preaspiration is paralleled by devoicing is confirmed, & lends further support to a cross-linguistic correlation between the two phenomena. In terms of which came first, all the available evidence (eg. Hansson 2001:164 for Scandinavia, & the absence of long stop devoicing in Italy) suggests devoicing of voiced stops typically develops some time after preaspiration of voiceless stops.

The unexpectedly high frequency of both phenomena in our data sample shows that they are not marginal in Sienese Italian. However, only one other source (Payne 1996) has observed preaspiration in Italian, & none reports stop devoicing, previous to our own work. The reason for this discrepancy appears to lie in the type of data traditionally used in experimental work on Italian, ie. controlled laboratory speech. We are the first to examine Italian stops in spontaneous speech. One problem with using such a corpus, however, is the low text frequency of long voiced stops in Italian. This factor appears to favour the use of controlled recorded data in any future investigation of stop voicing, but it also leads to the countervailing problem that the kind of phenomena (preaspiration & devoicing) we have uncovered may be masked by what seems to be a strong tendency for Italian speakers to perform towards a highly prescriptive & arguably artificial phonetic norm in controlled settings.

With respect to devoicing of long voiced stops, our results do not fully conform to expectations. While devoicing of long bilabials does occur at the predicted reduced rate, the absence of any significant effect of place of articulation (bilabial v. dental) on onset of devoicing & the great variability in the onset of bilabial devoicing are not expected. Both results are surprising when the phonetic basis for predictable interaction of place with stop devoicing seems so well-understood.

As to why the two phenomena of stop preaspiration & devoicing have developed in Sienese Tuscan, we offer a number of observations. In the first instance, we note the elevated speech rate typical of spontaneous spoken Italian (in Siena & elsewhere). The conflict between increased speech rate & the reduced available time for articulatory gestures it entails favours articulatory reduction in Sienese. This tendency has already been seen in the previously noted spirantization of intervocalic singleton stops in that dialect. In preaspirated geminate stops, speakers reduce the period of closure, but maintain the overall period of voicelessness. Preaspiration is used to keep voicing out of the transition from vowel to consonant in /VC:/ sequences (cf. Keating 2003). The effect is a kind of perceptual enhancement: although speakers produce [hp], given the long period of voicelessness, listeners are likely to interpret it as /pp/ rather than as /p/ or /(b)b/. With respect to partial devoicing of voiced

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geminates, speech rate will also have an effect. Since the vowel offset into the consonant is known to provide important acoustic information in Italian (Cerrato & Falcone 1998), the presence of voicing at this point, rather than later on in the consonant offset into the following vowel, will be sufficient to maintain the perceptual contrast between voiceless & voiced geminates in what are otherwise articulatorily difficult circumstances.

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