Consonant Length in Italian: Gemination, Degemination and Preaspiration

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1. Geminates in Italian

Standard Italian and all non-northern varieties of Italo-Romance are distinguished from most other Romance languages in having maintained historical consonant length contrasts from late Latin e.g. Italian *fatto* 'done', *palla* 'ball' v. *fato* 'fate', *pala* 'shovel'. The primary phonetic correlate of gemination in Italian is agreed to be a straightforward increase in consonant duration, although the relative duration of the preceding vowel plays an important perceptual role (e.g. Pickett et al. 1999). Specific to stop consonants, descriptive sources claim aspiration of any kind (i.e. preaspiration or postaspiration) does not occur in Italian, as in other Romance varieties, such that voiced /bb dd gg b d g/ contrast with unaspirated /pp tt kk p t k/ (e.g. Schmid 1999, Kramer 2009). Acoustic phonetic studies on standard Italian speech confirm this standpoint inasmuch as there is not typically any explicit discussion of aspiration. Pickett et al. (1999), for example, based their comparison of singleton and geminate stops at different speaking rates on closure duration values alone, and Esposito & Di Benedetto (1999) reported that voice onset time (VOT) durations were affected by vowel type and consonant place of articulation, but not by gemination. Payne (2005) on the other hand measured stop consonants to include "any voice-delaying aspiration", but did not investigate VOT durations separate from overall consonant durations. Overall therefore, an increase in consonant closure duration is agreed to be the primary phonetic cue to gemination in standard Italian.

Acoustic phonetic investigations into a corpus of spontaneous speech recorded in Siena (Tuscany), however, show that voiceless geminate stops /pp tt kk/ can be produced with aspiration preceding consonant closure, namely preaspiration e.g. *fatto* [fahto] (e.g. Stevens & Hajek 2007). (Post-aspiration, while not the focus of our present study, was also visible in that corpus and has recently been documented for geminate stops in standard Italian (Stevens & Hajek 2010)). For preaspirated stops, Stevens & Hajek (2004) found the mean closure duration was 32ms shorter than for stops with phonetically long supralaryngeal closure in the same corpus. In other words, a primary acoustic and perceptual cue to gemination appears to be much less robust when preaspiration occurs, which raises the question as to whether preaspiration might constitute a weakening of /pp tt kk/ in Sienese Italian. Evidence from perceptual and articulatory studies on other languages suggests that once present in a language's sound system, preaspiration is a somewhat unstable variant (see below). This instability is of special interest in the context of Romance phonology given that degemination has occurred in varieties spoken in the north of Tuscany and elsewhere in the Romance-speaking world e.g. late Latin UACCA(M) > Spanish /baka/, northern Italian /vaka/, French /vaʃ/; but standard Italian /vakka/ 'cow'.

Preaspiration is not confined to Sienese Italian, however. A preliminary study based on read standard Italian speech recorded in fifteen Italian cities found preaspiration amongst /pp tt kk/ tokens from each location (Stevens 2010). Based on frequency counts, that preliminary study concluded that preaspiration is an evident tendency for native speakers from across Italy when speaking standard Italian. The present study extends that preliminary research to consider whether preaspiration in

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standard Italian should be treated as lenition, perhaps leading to degemination of /pp tt kk/, or whether it better constitutes a reinforcement of the geminate stops.[1]

2. Preaspiration as lenition or fortition

Preaspiration is a rare phenomenon in the world's languages, especially compared with post-aspiration. Preaspirated stops are perceived as having a portion of breathiness before consonant closure, the archetypal realization of which involves voiceless glottal frication [h] (see e.g. Silverman 2003; Helgason 2002 for detail on preaspiration), which is known to be hard for listeners to hear (e.g. Bladon 1986; Mielke 2003 for a cross-linguistic study involving /h/). The evidence in the literature is mixed as to whether preaspiration constitutes weakening or strengthening of stops, a point which of course depends on whether they are evaluated in articulatory, acoustic or perceptual terms. Lavoie (2002:45) does not specifically address preaspiration but describes lenition or reduction as any form involving less oral closure than the citation form. Given the supralaryngeal closure gesture is typically shorter for geminates produced with preaspiration than without, preaspiration can be seen as lenition of long voiceless stops through debuccalization. This analysis is favoured by Kirchner (1998:143) who treats preaspirated stops in Icelandic as h+C clusters, that is, weaker than the geminate stops from which they arose. Within Articulatory Phonology (e.g. Browman & Goldstein 1991) preaspirated stops are viewed as an unstable variant because the production of glottal and supralaryngeal gestures is sequential, rather than synchronous (in-phase) as for a plain unaspirated stop (e.g. Parrell 2009). The low perceptual salience of preaspiration also favours its interpretation as a weakening process, and indeed there is evidence that over time preaspiration can be replaced with contrastive vowel length i.e. /VhC/ > /V:C/ (Silverman 2003). If preaspiration of /pp tt kk/ is indeed a lenition process then we would expect it to be more frequent in contexts typically associated with lenition – that is, in more casual speech styles and in less prosodically prominent environments. Descriptive work by Gildea (1995:87) shows this to be the case in Makushi, a Cariban language, where preaspiration arises in unstressed syllables in fast casual speech (e.g. *appó* [a^{h}ˈpo] 'fire').

On the other hand, in Central Standard Swedish preaspiration is more frequent and of longer duration in stressed contexts (Helgason 1998), suggesting preaspiration behaves as a fortition process in prosodically prominent contexts. Phrase boundaries can also affect the frequency of preaspiration: in Newcastle English for example, /t/ is reinforced with preaspiration in phrase-final position e.g. *kite* (Foulkes et al. 1999), and phrase-final fricatives are often realised with preaspiration in Scottish English e.g. *grass* (Gordeeva & Scobbie 2010). Based on their phonetic results, Gordeeva & Scobbie conclude that in Scottish English preaspiration is a mechanism to enhance the voicing contrast in phrase-final position. Here phrase-final preaspiration appears to pattern with some devoicing processes in other languages, such as devoicing of nasals in Romanian, which have also been treated as a kind of prosodic domain strengthening (see Tucker & Warner 2010:316 for detail on the interpretation of devoicing processes as fortition or lenition). In languages with a fortis/lenis contrast involving consonant length, preaspiration can occur on both series but is typically more frequent and more intense for the fortis member (e.g. Tronnier 2002, Helgason 1998, 2002 on Swedish, DiCanio 2008 on San Martín Itunyoso Trique). Preaspiration has to date only been documented for geminate /pp tt kk/ in standard Italian; singleton /p t k/ in the same corpus are yet to be closely examined.[2] Nonetheless, as described earlier aspiration of any sort is not generally considered a phonetic cue to phonological stop

[1] Joaquín Romero (pers. comm.) points out that identifying preaspiration as either fortition or lenition assumes a belief in an underlying teleological force that would strive to either preserve or undermine the geminates in Italian. The particular research question addressed in the present paper was motivated by the literature on preaspiration which suggests that it can play a role in enhancing fortis-lenis distinctions (e.g. Helgason 1998). In addressing this question I do not intend to imply that the production of individual /pp tt kk/ tokens with preaspiration is goal-oriented, but rather that preaspirated /pp tt kk/ may have (unintended) consequences for the system of contrastive sounds in Italian.

[2] Comparison of singleton and geminate stops is complicated by widespread lenition of intervocalic singletons in spoken Italian (see e.g. Villafaña-Dalcher 2008 on singleton /p t k/ in Florentine Italian), preventing a straightforward duration-based analysis. With much regional variation, this task is further complicated when speakers from different regions are involved, as in the corpus analysed here.

contrasts in standard Italian. Therefore it is not clear why geminate /pp tt kk/ would be produced with preaspiration or indeed whether these realisations are necessarily a form of enhancement of the geminate series.

3. Aims

This paper investigates whether preaspiration should be treated as an enhancement of geminate /pp tt kk/ in Italian or, on the other hand, whether there is acoustic evidence that preaspirated stops are weaker than their plain counterparts. To do this, we compare the duration of preaspirated and plain stops and examine whether preaspiration interacts with prosodic structure. Given the cross-linguistic observations made above, if preaspiration is more frequent with lexical stress and in phrase-final contexts, then we would assume speakers employ it as a reinforcement of the geminate consonant. On the other hand, if voiceless stops /pp tt kk/ are more frequently produced with preaspiration in unstressed positions, preaspiration should be seen as a phonetically weaker realisation of /pp tt kk/ for Italian speakers. The overall aim here is to understand why geminates are produced with preaspiration and what the consequences of this synchronic variation may be for the phonological length contrast in Italian. The paper also contributes to our knowledge of preaspiration and what its presence as a synchronic variant may mean for phonological contrasts in Italian as well as in other languages.

The existence of preaspirated voiceless geminate stops /pp tt kk/ in Italian of course raises many other questions such as its potential role in voice and length contrasts (i.e. [hp ht vk] v. /bb dd gg/ and /p t k/), the timing relationships between glottal and supraglottal gestures that give rise to preaspiration, and its relationship to post-aspiration. These questions cannot all be addressed here for various reasons (including limitations associated with the corpus noted at §4.1, and see Footnote 2) but this paper is only part of an ongoing project with perceptual and production tests planned to complement the acoustic evidence described here.

4. Methods

4.1. The data

The data analysed here were drawn from the CLIPS corpus of spoken Italian (www.clips.unina.it; Savy & Cutugno 2009), a large-scale corpus of read and spontaneous standard Italian speech recorded in fifteen Italian cities. Here we analyse only read speech data, involving occurrences of /pp tt kk/ tokens in a list of isolated words (n = 935) and in two phrases (n = 472). The isolated words comprise *bocca* 'mouth', *bottoni* 'buttons', *cappello* 'hat', *macchina* 'car', *occhi* 'eyes', *specchietto* 'little mirror' and *tetto* 'roof'.

As noted earlier we are also interested in the impact of phrase position on preaspiration, and with this in mind we also analyse /et:/ sequences in two phrases read by the participants, which were as follows (with the words containing /et:/ underlined):

Un mese di vacanza passa in <u>fretta</u> 'A month of holidays goes in a hurry'

Dopo tanto tempo non ricordo più dove ho messo quella bella foto, ma se <u>aspetti</u> un po' la cerco e te la prendo 'After a long time I don't remember where I put that beautiful photo, but if you wait a moment I'll look for it and bring it to you'

The words and phrases were read once by 8 speakers in each city (see www.clips.unina.it for documentation on recording procedures. No information is given within this documentation about whether participants were instructed on speaking rate, but my impression was of fluent, relatively fast read speech). The final number of tokens analysed here varied slightly for each city as some tokens were discarded due to background noise or incomplete pronunciations (e.g. /fret:a/ > [fre] in phrase-final position). These data were not designed for the purposes of the current experiment and there are some drawbacks (e.g. amongst the isolated words there are no voiced geminate stops for comparison). Nonetheless the CLIPS corpus was ideal in other respects, primarily because it affords examination of

a large number of speakers of standard Italian from different regions of Italy.[3]

4.2. Labelling procedures

The individual word data were labelled manually using both Emu (Harrington 2010) and Praat (Boersma & Weenink 2010). Based on the auditory percept and on visual inspection of the acoustic display, up to four duration values were recorded for each /VC:/ sequence: the vowel, preaspiration (where present), supralaryngeal closure, and release (release burst plus any post-aspiration).

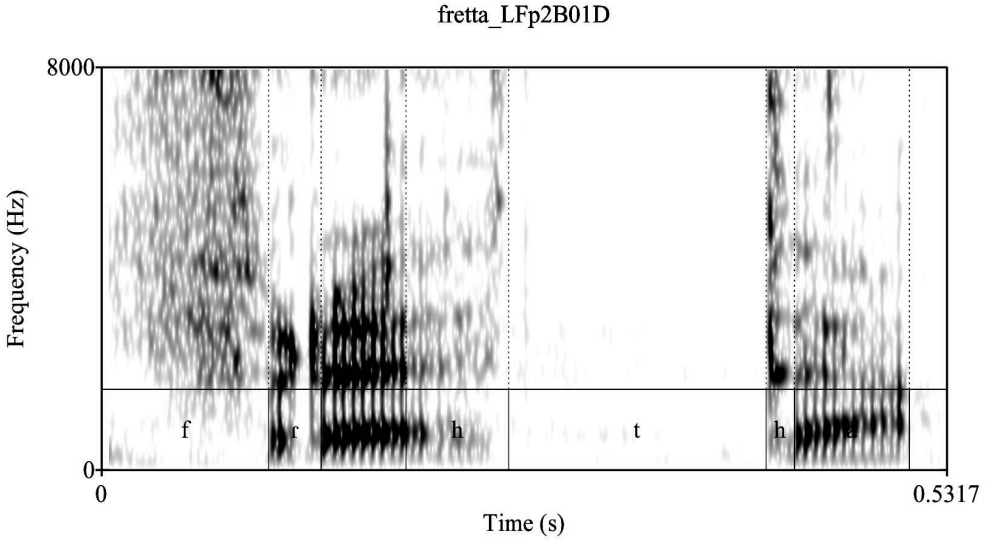

Figure 1. A voiceless geminate stop /tt/ in phrase-final *fretta* 'haste' produced with preaspiration by a female speaker from Bergamo. Preaspiration is visible as a period of dispersed spectral energy labelled 'h', between modal voicing for the vowel and the closure portion labelled 't'. The duration of preaspiration is 64.6ms.

As seen in Figure 1, the preaspiration portion was measured from the offset of modal voicing in the vowel to the onset of closure. That is the onset of breathy voice rather than the offset of voicing was taken to be the primary criterion for the onset of preaspiration (consistent with other phonetic literature on preaspiration e.g. Helgason 2002).

The phrases were first labelled semi-automatically using the Munich automatic segmentation tool (Schiel 2004) in order to identify the target geminate consonants. VOT and preaspiration were subsequently labelled manually in Emu speech database system, following the same criteria described above for the isolated word data.

Statistical analysis was conducted in Emu/R (Harrington 2010). The frequency of preaspiration was analysed using a generalized linear mixed model with one of region, lexical stress or phrase position as the dependent variable and speaker as a random factor. The duration values were analysed with a linear mixed model, with preaspiration duration as the dependent variable, and again with one of region, lexical stress or phrase position as the independent variable and speaker as a random factor. Here F values of 8.49 and over were treated as significant, following Reubold et al. (2010).

5. Results

5.1. Preaspiration of geminate /pp tt kk/

We first compare /pp tt kk/ tokens produced with and without preaspiration in the isolated word

[3] Standard Italian is a controversial concept and it is difficult to find speakers of standard Italian unmarked by regional features, particularly at the phonetic level (e.g. Bertinetto & Loporcaro 2005 on standard Italian, among others). Therefore it is necessary to consider speaker region of origin, especially when investigating fine-grained differences in consonant production.

data. Overall 252 of these 935 (27%) voiceless geminate stops were produced with preaspiration, which itself had a mean duration of 48.4ms.

	Vowel	Pre.	Clo.	Rel.	Pre+Clo+Rel	n
VhC	98.1 (28)	48.4 (19)	154.4 (48)	52.8 (28)	255.6 (44)	683
VC:	101.5 (38)	n/a	183.3 (45)	44.3 (38)	225.8 (44)	252
All	100.6 (35)	n/a	175.5 (47)	46.6 (35)	233.8 (46)	935

Table 1. Mean duration values (in ms) and standard deviations in parentheses for vowel + /pp tt kk/ sequences with (VhC) and without (VC:) preaspiration. The duration of the release phase listed as "Rel." includes the release burst and any post-aspiration.

In terms of the impact of preaspiration on surrounding segments, no significant difference was found for the duration of the preceding vowel, which remains stable whether preaspiration occurs or not in these data ($F[1, 60]=1.0336$, $p > 0.05$). The presence of preaspiration has a greater effect on the other components of vowel + /pp tt kk/ sequences listed in Table 1. In particular, the mean closure duration is significantly shorter when preaspiration occurs ($F[1, 60] = 108.59$, $p < 0.001$), while the release portion is significantly longer ($F[1, 60] = 28.29$, $p < 0.001$).[4] When the component parts of the stop are summed to give overall consonant duration values (preaspiration + closure + release), the difference between preaspirated stops and their plain counterparts is also significant ($F[1, 60] = 75.333$, $p < 0.001$).

Before focusing on the interaction between preaspiration and prosodic structure it is necessary to consider the impact of speakers' region of origin. While earlier work on this corpus has showed that speakers from all 15 cities produce preaspirated stops (Stevens 2010), Northern speakers are reported to shorten geminates when speaking standard Italian (Bertinetto & Loporcaro 2005). The interaction between these two patterns, if any, may shed light on the question of whether preaspiration involves weakening or strengthening of voiceless geminate stops. With this in mind the data were divided according to whether the speaker was from Northern (Bergamo, Venice, Parma, Genova, Turin, Milan), Central (Perugia, Florence, Rome) or Southern Italy (Catanzaro, Napoli, Palermo, Cagliari, Lecce, Bari). Focusing here on preaspiration, Table 2 lists the frequency and mean duration for preaspiration across the three regions.

	Frequency: preaspiration	Mean duration: preaspiration	Mean duration: overall C
North	102/374 (27.3%)	49.1ms (22ms)	232.7ms (48ms)
Central	58/181 (32.0%)	48.7ms (19ms)	236.2ms (43ms)
Southern	92/380 (24.2%)	47.4ms (16ms)	233.7ms (46ms)
All	252/935 (27%)	48.4ms (24ms)	233.8ms (46ms)

Table 2. Frequency and mean duration of preaspiration according to speaker region of origin (Northern, Central or Southern) in the isolated word data. The mean overall duration for the consonant portion (whether preaspirated or plain) is listed in the right-hand column. Standard deviations in parentheses.

No significant differences were found across the three groups in terms of the frequency of preaspiration: North v. Central $z = 0.7992$, $p > 0.05$; North v. Southern $z = 0.873$, $p > 0.05$; Southern v. Central $z = 1.5090$, $p > 0.05$. Similarly we can see in Table 2 that the duration of preaspiration remains stable across the three groups, and statistical tests found no effect of region on preaspiration durations ($F[1, 60] = 0.3539$, $p > 0.05$).

[4] As noted at §1, post-aspiration was frequently visible, and audible, and has been documented for part of this corpus of standard Italian (Stevens & Hajek 2010), however the question of whether preaspiration and post-aspiration durations interact is yet to be addressed for these data.

Additionally, as seen in Figure 2, speaker region of origin does not have a significant effect on overall consonant duration values (preaspiration + closure + release) within the preaspirated tokens ($F[1, 60] = 0.4358, p > 0.05$) or when all tokens were combined ($F[1, 60] = 0.0366, p > 0.05$). In other words speakers from northern Italy, for whom degemination is reported to be a regional feature, produce geminate consonants that are fully comparable in terms of duration to those produced by speakers from elsewhere in these standard Italian words read in isolation (see also §6 on this point).

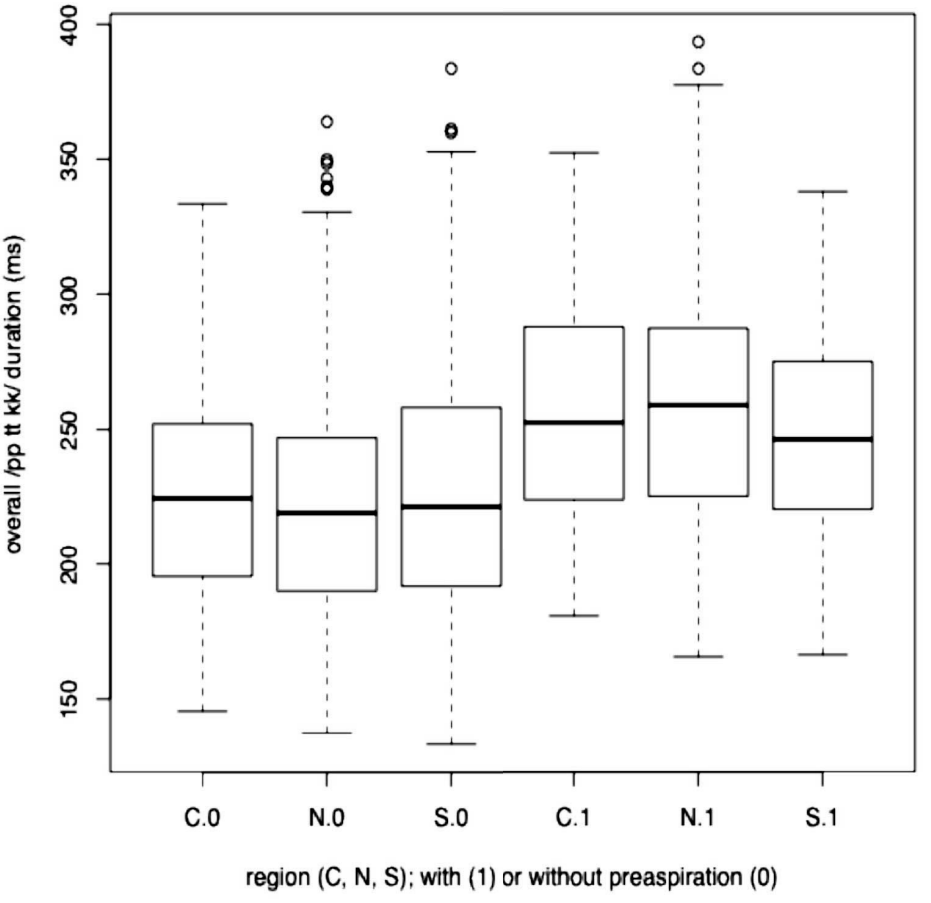

Figure 2. Mean durations for the overall consonant portion (preaspiration + closure + release) according to speaker region of origin (Central, Northern, Southern) and preaspiration (to the left 0 = no preaspiration; to the right 1 = preaspirated /pp tt kk/ tokens).

5.2. Preaspiration and lexical stress

The isolated word tokens were divided according to whether the preceding vowel was lexically stressed (e.g. *bocca* 'mouth') or not (e.g. *bottoni* 'buttons'). Note that lexical stress was always realized phonetically, as these data involve words read in isolation. Table 3 lists the frequency of preaspiration and its mean duration value for both prosodic contexts.

Preceding V	Frequency preaspiration	Mean duration preaspiration
Stressed	194/582 (33%)	52.8ms (17ms)
Unstressed	58/353 (16%)	33.8ms (18ms)
All	252/935 (27%)	48.4ms (19ms)

Table 3. Preaspiration frequency and mean duration according to whether the previous vowel was stressed or unstressed.

Table 3 shows that preaspiration is twice as frequent after lexically stressed than after unstressed vowels, and a generalized linear mixed model confirms this difference to be highly significant (z = 6.315, $p < 0.001$). The duration of preaspiration is also significantly longer after stressed than unstressed vowels in these data ($F[1, 60] = 61.048$, $p < 0.005$). The overall consonant duration values are also longer after stressed vowels: Figure 3 shows the mean overall duration values for stop consonants according to stress and preaspiration.

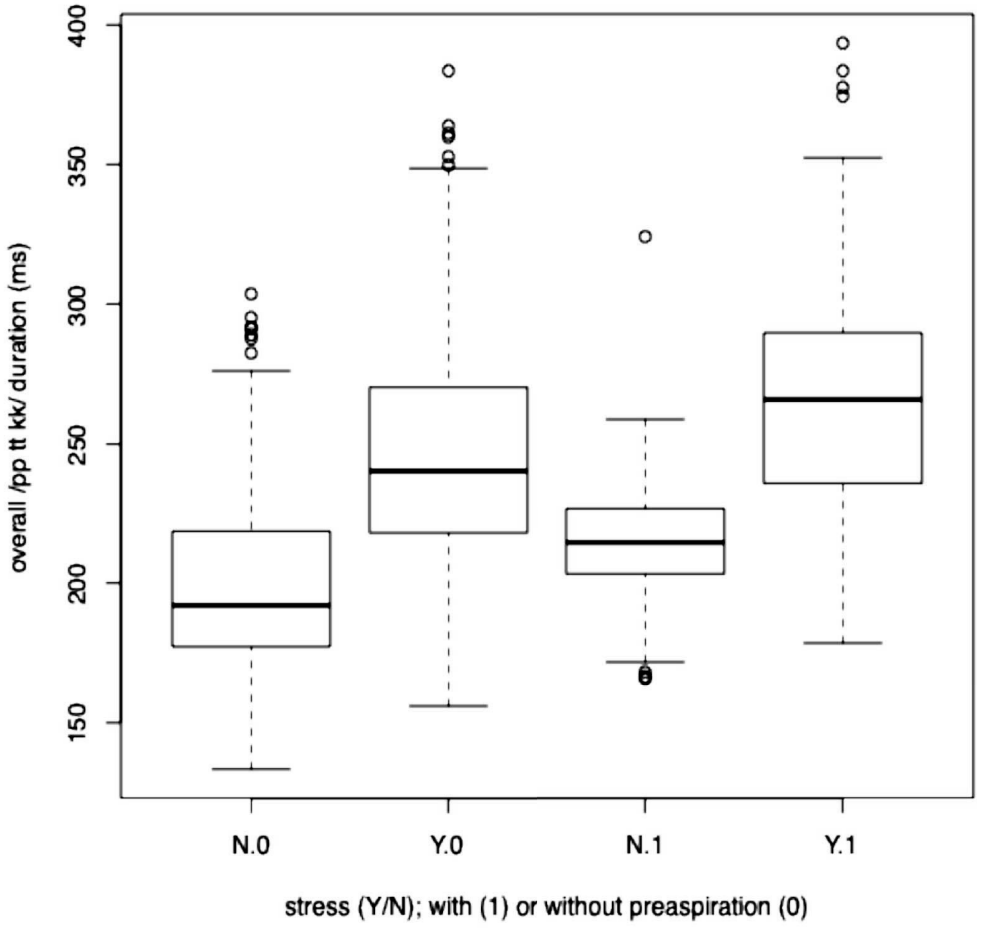

Figure 3. Duration of the overall consonant portion (preaspiration + closure + release) according to stress (0 = unstressed, 1 = stressed) and whether preaspiration occurred or not (Y=preaspirated, N=plain).

Consonants are longest with stress and with preaspiration, as shown in the far right-hand bar of Figure 3. It appears therefore that preaspiration serves to enhance the voiceless geminate stop after lexically stressed vowels in these isolated words. To further understand the relationship between preaspiration and prominence, we now turn to the read phrase data.

5.3. Preaspiration and phrase boundaries

Table 4 lists the frequency and duration of preaspiration in a geminate dental stop /tt/ that occurred in words in phrase medial and phrase final positions. The structure of the corpus did not allow the same word to be analysed across the two phrases (in one case *fretta* 'haste' and in the other *aspetti* 'you wait'), but potentially impacting factors were controlled as far as possible. More specifically the sequence chosen was in both cases /ett/, allowing vowel height and consonant place to

remain the same across comparisons, and in both phrases the preceding vowel is lexically stressed (phrase-final *fretta* also has nuclear stress – which falls on the final lexically stressed syllable Italian - whereas in phrase-medial position *aspetti* does not). To allow comparison with the data analysed in the preceding sections, Table 4 also lists values for the word *tetto* 'roof', which formed part of the word list data read in isolation.

/et:/	Preaspiration frequency	Preaspiration duration
Phrase final *fretta*	61/234 (26%)	40.9 (25.9ms)
Phrase medial *aspetti*	17/238 (7%)	23.8ms (9.1ms)
(isolated word) *tetto*	32/118 (27%)	44.0ms (15.5ms)

Table 4. The frequency of preaspiration in /et:/ sequences in phrase final and phrase medial contexts. Mean duration values are also listed. Standard deviations in parentheses).

We can see that preaspiration is nearly four times as frequent in phrase-final *fretta* than in phrase medial *aspetti*, for which it occurs in only 7% of tokens. Reflecting the fact that words read in isolation each constitutes its own utterance, preaspiration occurs at a similar rate in isolated word tokens as in phrase-final position. Statistical analysis showed the difference in frequency between phrase-medial *aspetti* and phrase-final *fretta* to be highly significant ($z = 5.173$, $p < 0.000$), and the mean duration value for preaspiration is nearly twice as long in phrase-final position, a highly significant difference ($F[1,60] = 931.92$). All of these results suggest that preaspiration is linked specifically to prosodic prominence in standard Italian – to the phrase-final word position or to the nuclear stress that accompanies it.

Subsequent closer inspection of the twelve phrase-medial tokens with preaspiration showed that in one case a speaker inserted a pause after *aspetti, ma se aspetti, …un po'* 'but if you wait, …a bit'. This is seen in Figure 4, below, where a pause is visible as glottalization at the offset of the vowel /i/, between *aspetti* and *un* (realized phonetically as [m]).

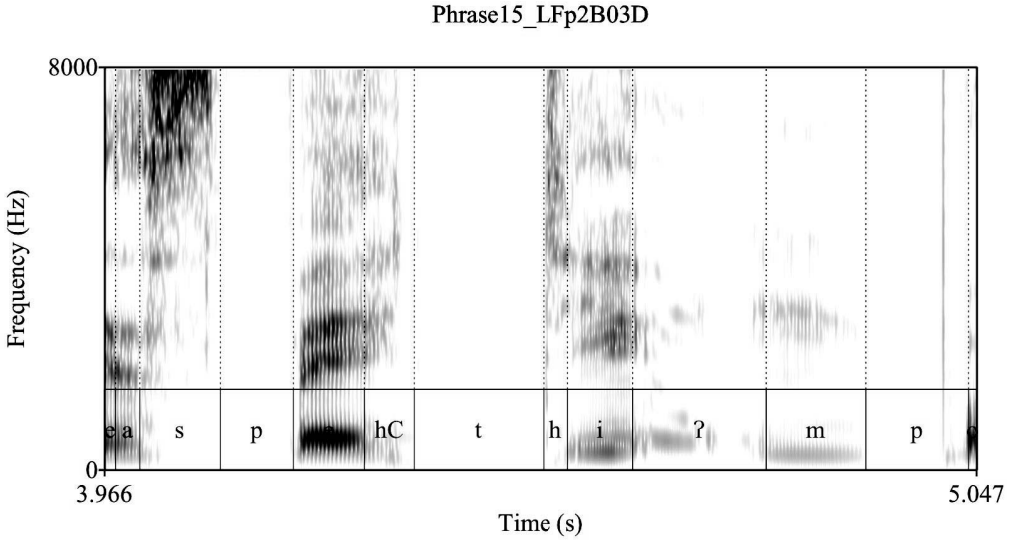

Figure 4. The sequence *aspetti un po'* 'wait a bit' with preaspiration (labeled hC) preceding the closure for the dental geminate /tt/. Preaspiration was otherwise rare when a pause was not inserted between *aspetti* and the following word. The duration of preaspiration, labeled hC, is 50.5ms in this case.

In terms of trying to understand why preaspiration occurs where it does in these Italian data, it is worth noting this token because perhaps the insertion of a pause helps to trigger preaspiration of the preceding voiceless geminate stop /tt/. However preaspiration can nonetheless occur in non-phrase-final contexts: in the other eleven *aspetti* tokens in which geminate /tt/ was preaspirated, the speaker did not pause before the end of the complete phrase. In sum, these preliminary data show that

preaspiration is more likely, but not obligatory in phrase-final position and can occur albeit much less often in phrase-medial contexts.

6. Discussion: preaspiration as strengthening or weakening?

Native Italian speakers produce just under one third of voiceless geminate stops in isolated words with preaspiration, as seen in Table 1 earlier. The very fact that preaspiration occurs in these controlled speech data, involving read lists of words and phrases from the standard variety, is perhaps itself an indicator that preaspiration is a kind of enhancement in controlled or more careful speech. Nonetheless, the effect of speech rate on the production of voiceless stops with or without preaspiration is yet to be tested in a controlled study (and recall §4.1 on speech rate in the present corpus). Table 5 summarizes the main results of the preceding sections, in terms of whether preaspiration should be treated as fortition and lenition.

Frequency of preaspiration:		**Fortition or lenition**
- Region	No difference	---
- With lexical stress	More frequent	Fortition
- Phrase-final position	More frequent	Fortition
Duration preaspirated v. plain:		
- Vowel	No difference	---
- Closure	Shorter with preaspiration	Lenition
- Overall C duration	Longer with preaspiration	Fortition

Table 5. Summary of the results presented in the preceding sections. The right hand column considers the results according to whether geminate stops are weaker or stronger when produced with preaspiration than with a phonetically long closure in the oral tract as expected for standard Italian.

Looking first at the frequency data, we saw that the tripartite division into Northern, Central and Southern regions showed no significant interaction with preaspiration[5], and speakers from Northern Italy, in particular, produce geminate /pp tt kk/ with preaspiration at a similar rate to speakers from elsewhere in Italy. Remembering that Northern speakers often tend to shorten geminates even when speaking standard Italian (Bertinetto & Loporcaro 2005), the results presented here favour the interpretation of preaspiration as a kind of articulatory reinforcement of /pp tt kk/. Specifically, the fact that Northern speakers preaspirate suggests it may be a strategy to enhance or exaggerate geminates for speakers who in less controlled contexts might not normally produce them as phonetically long. Nonetheless, the interaction between preaspiration and regional variety needs to be more thoroughly investigated based on regional as well as standard Italian speech data.

The interaction between preaspiration and prosody, on the other hand, showed clearer patterns in these data in terms of its interpretation as fortition or lenition. Preaspirated stops are closely associated with strong prosodic positions: they are more frequent following lexically stressed vowels (e.g. *occhi* 'eyes'), and more frequent at phrase boundaries than in phrase-medial position. In addition to these quantitative data, we also saw that in the only case where a pause was inserted after *aspetti* in *aspetti un po'*, the voiceless geminate /tt/ was produced with preaspiration. In this sense, pre-pausal position appears to be able to trigger preaspiration where it doesn't otherwise tend to occur. We saw earlier that preaspiration is associated with phrase-final position in other languages e.g. Scottish English, for which preaspiration serves to enhance the phonological voice contrast (Gordeeva & Scobbie 2010). In our data preaspiration appears to pattern the same, although such an interpretation requires analysis of voiced geminates /bb dd gg/ in the same phrase-final context to determine whether these are also preaspirated or whether it helps to distinguish the voiceless /pp tt kk/ series.

While our frequency data show that speakers produce geminate voiceless stops with preaspiration in prosodically strong contexts, when we consider duration values it is not clear that this (assumed)

[5] There is variation within each region, as detailed in Stevens (2010), for example preaspiration is more frequent in Bari than in Catanzaro, both of which are in Southern Italy.

articulatory enhancement would necessarily translate to native listener perception. The impact of preaspiration on the perception of phonological length in Italian is yet to be experimentally addressed, but preaspiration is known to be hard to hear because it shares many spectral properties with the preceding vowel, and as noted earlier, has been replaced with vowel length contrasts i.e. VhC > V:C in other languages. Native Italian listeners are known to rely strongly on supralaryngeal closure duration to perceive phonological consonant length for stops (Pickett et al 1999; Esposito & Di Benedetto 1999); in Table 1 we saw that the mean closure duration was 28.9ms shorter for preaspirated stops, a significant difference that is shown schematically in Figure 5 for bilabial /pp/.

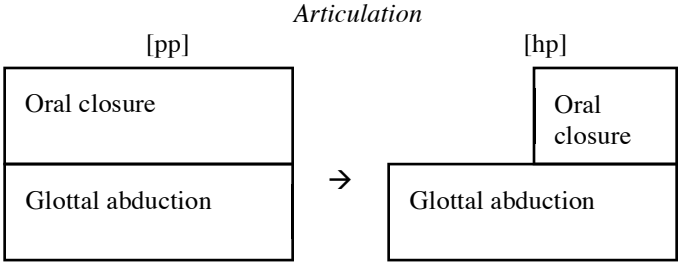

Figure 5. Schematic representation of the oral and glottal gestures for phonetically long stops [pp] and for preaspirated stops [hp] (reproduced from Kirchner 1998).

Perception tests involving preaspirated and plain stimuli such as [pp] and [hp] in Figure 5 are needed to determine whether native listeners attend (a) only to the supralaryngeal closure portion, perceiving preaspirated [hp] as phonologically short, or (b) to the onset of voicelessness resulting from the early glottal abduction gesture, in which case the preaspirated [hp] would be perceived as phonologically long /pp/. In sum, there may be a mismatch between production (preaspiration = more fortis) and perception (more lenis) that could possibly lead to degemination in standard Italian. This suggestion is not intended to imply that degemination is an intended goal for native speakers or for the system itself. However, given preaspirated stops are an allophonic variant of geminate /pp tt kk/, one potential outcome, via listener misperception, may be degemination which has of course occurred in regional varieties spoken in Northern Italy and in other Romance languages.

Leaving the shorter closure durations to one side, when we consider other acoustic measures the preaspirated stops are more robust. Specifically, we saw that the mean overall consonant durations (preaspiration + closure + release) are longer for preaspirated stops. This particular result is important because across different speaking rates native Italian listeners are known to be most sensitive to a higher order measure: the ratio between the consonant duration and that of the preceding vowel (Pickett et al. 1999). Table 6 relates Pickett et al.'s findings to the present corpus of isolated word data, taking "consonant duration" to be preaspiration + closure + release, that is, the entire glottal abduction gesture shown earlier in Figure 5.

	V duration	C duration	C : V ratio	*n*
Stressed				
- Preaspirated [hC]	108.3	267.6	2.60	194
- Plain [C:]	128.2	253.5	2.20	388
Unstressed				
- Preaspirated [hC]	64.2	215.1	3.49	58
- Plain [C:]	66.2	201.2	3.20	295

Table 6. Mean vowel duration and consonant durations in ms. for /pp tt kk/ tokens in isolated words (*n* = 935) according to stress and +/- preaspiration. The consonant/vowel ratio value is also listed.

Pickett et al. (1999) found that for a stressed /VC:/ sequence to be perceived as long, the consonant must be at least as long as the preceding vowel (a C/V ratio of 1.0), while in unstressed sequences the consonant must be twice as long (a ratio of 2.0). Table 6 shows that C/V ratios for these

data are in all cases above the threshold values; what is of interest here is that the preaspirated stops have higher values for the C/V ratio measure than their plain counterparts, in both stressed and unstressed contexts. In other words, based on this measure the preaspirated stops appear to be perceptually stronger than plain phonetically long [pp tt kk]. However whether these acoustic duration measures actually relate to native listeners' perception of preaspirated stops is yet to be tested in a controlled experimental perceptual study. Keeping in mind the generally weak perceptual cues to preaspiration, noted earlier, it is not clear whether they would in fact include preaspiration in the overall duration of the consonant as we have done here.

7. Conclusions

The acoustic evidence presented in this study shows that in standard Italian, voiceless geminate /pp tt kk/ are optionally produced with preaspiration. Given the presence of aspiration contrasts with traditional descriptions of Italian as a "true voice" language with unaspirated voiceless stops, we attempted to investigate why preaspiration would arise and whether it is a weakening or strengthening process. Our acoustic results favour the idea that speakers employ preaspiration as an enhancement of the geminate /pp tt kk/ series: preaspiration is more frequent in prosodically prominent locations, that is, with lexical stress and in phrase-final, nuclear stressed position. While preaspirated stops have shorter closure durations than the plain stops with phonetically long closure [pp tt kk], they appear to be more robust in terms of the other absolute and relative duration measures considered. Nonetheless, we noted that the question of whether preaspiration is to be interpreted as a strengthening or weakening process depends on articulatory and perceptual as well as acoustic criteria. The close association between preaspiration and prosodic prominence in these data favours its interpretation as articulatory fortition, however this interpretation needs to be directly tested in a production study. In perceptual terms, our non-experimental perceptual observations supported the interpretation of preaspiration as fortition, given the higher-order temporal measure to which native listeners attend (namely the consonant:vowel (C/V) ratio) is more robust when /pp tt kk/ were produced with preaspiration. However in calculating the C/V ratio we included preaspiration in the overall duration of the consonant portion; controlled perceptual tests are needed to determine whether native Italian listeners would do the same.

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