VOICELESS STOPS IN SYLLABLE CODA IN TUSCAN ITALIAN

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ABSTRACT

In Tuscan varieties of Italian, postvocalic stop consonants are affected by a spirantization process (*gorgia toscana*). In current literature, stops have been analysed in syllable onset only, while no studies examined the coda context. Our study examines the phonetic outputs of /k t p/ in coda in order to verify whether the postvocalic position is a sufficient constraint for *gorgia* to apply. Although Italian words derived from Latin do not allow a stop in coda position, items like *cactus* and *taxi* are now well integrated in the Italian lexicon, being frequently produced by speakers. We recorded 24 Florentine speakers and built a corpus of 474 postvocalic voiceless stops occurring in two different contexts: 168 consonants in coda position (e.g. *cactus* "cactus") and 288 occur in onset position (e.g. *oca* "goose"). The results of the acoustic analysis (including duration and intensity of the target segments) show a stop output in coda position for all speakers, providing further evidence for the syllable constraint.

Keywords: Italian, lenition, Tuscan, syllable, acoustics

1. INTRODUCTION

In Tuscan varieties of Italian, stop consonants are affected by a regular weakening process when occurring in postvocalic position, i.e in onset position, given that in the native lexicon stops cannot occupy the coda position (cf. [1; 2; 3; 4; 5; 6; 7]).

The process gives rise to fricative segments and occurs not only in word intervocalic context (e.g. [ˈaːɸe] *ape* "bee", [ˈdiːθo] *dito* "finger", [ˈɔːxa] *oca* "goose", [ˈau̯θo] *auto* "car", [ˈbai̯θa] *baita* "cabin") but also when the stop is followed by a liquid or a glide (e.g. [ˈkaːɸra] *capra* "goat", [ˈaːxre] *acre* "acrid", [riˈxjaːmo] *richiamo* "recall", [ˈaːxwila] *aquila* "eagle"). In literature this spirantization process is traditionally named *gorgia toscana* (henceforth GT). Voiceless plosives are the preferred target for GT. Amongst Italian speakers, the lenition of /k/ is considered the prototypical feature of Tuscan, since such weakening process mostly affects /k/ with respect to /t/ and /p/ in all the region of Tuscany.

In Italian as well as in Tuscan lexicon derived from Latin, a stop may only be followed by a vowel, a liquid, or a glide. Since all these segments do not block GT, the process appears to be constrained only by the left side of the string. Therefore, the triggering context of GT may simply be defined as postvocalic (cf. [6]; [7]). The lenition process is thus blocked if the stop is either geminated (e.g. [ˈgatːo] *gatto* "cat", [ˈtapːo] *tappo* "cap",) or preceded by another consonant (e.g. [ˈarko] *arco* "arch", [ˈkampo] *campo* "field"). Stops remain stable even in absolute initial position of an utterance, i.e. after a pause.

In some loanwords a voiceless stop may be followed by another stop (e.g. *cactus* "cactus" [ˈkaktus], *captato* "intercept" [kapˈtaːθo]), a fricative (e.g. *taxi* "taxi" [ˈtaksi]) or a nasal segment (e.g. *ritmo* "rhythm" [ˈritmo], *acne* "acne" [akne]). In these cases, the stop can be associated with a syllable coda. However, from a general point of view it is possible that the clusters stop + *s* or *n*, *m* could be interpreted as branching onsets, since they respect the Sequencing Sonority Principle [8]. It has to be underlined that nowadays lexemes like the ones aforementioned are well integrated in the Italian lexicon, since they are frequently produced by speakers in every register of the language, especially for young people.

In current literature on GT, stops have been analysed in syllable onset only, that is with reference to words belonging to the native lexicon derived from Latin. Up to now there are no acoustic studies that have examined the context where the target consonant is followed by an obstruent or a nasal. On the assumption that GT applies when the stop associated with a postvocalic onset position, we may expect that the target consonant will be not affected by GT if it is associated with syllable coda. As we shall see, our acoustic results will show that stops in this specific context do not undergo GT, thus confirming the role played by syllable structure in this lenition process, as already proposed by [6] and [7]: stops are a target for GT only in postvocalic onset position.

2. METHOD

Our study includes 24 Florentine participants (12 females and 12 males) who were born in Florence and have never moved to other cities, and whose parents were born in town as well. Age ranged from 29 to 64 years, whereas education varied from lower-level secondary diploma to master's degree. Speech material was recorded at 48 kHz 24 bit mono, using a Shure headset microphone, which guaranteed a constant distance of the microphone from the speaker, connected to a Zoom H2next recorder. The participants have been recorded in a quiet room. They were asked to read randomised sentences with target words including voiceless stops (the main target of GT [1; 2],), both in stressed and unstressed syllables.

The global corpus is composed of 474 postvocalic voiceless stops: 168 /k/, 168 /t/ and 138 /p/. 168 consonants occur in coda position: 72 /k/, 72 /t/ and /42 /p/ (e.g. *cactus* "cactus", /ˈkak.tus/, *ritmo* "rhythm" /ˈrit.mo/), whereas 288 occur in onset position (96 for each place of articulation); e.g. *buca* "hole", /ˈbu.ka/; *foto* "photo", /ˈfɔ.to/). The acoustic analysis was performed using PRAAT [9] with the help of webMAUS [10] for supervised alignment. Following [11] and [12] we classified the acoustic outputs of each target segment as follows:

a) **stop** (i.e. [k t p]): silence followed by spike and release phase; see Figure 1;
b) **fricative** (i.e. [x/h θ ɸ]): frication noise through all phone duration without voicing; see Figure 2;
c) **approximant** (i.e. [ɣ/ɦ ð β]): frication noise with voicing (and visible formant structure); see Figure 3;
d) **deletion** of the segment: no acoustic quality typical of the consonant between the preceding vowel and the following segment; see Figure 4;
e) **assimilation** (e.g. /kt/ > [tː]): production of the following consonant as long, i.e. geminated; see Figure 5.

We also found segments in which the frication noise was preceded by a brief hold phase (around 30 ms; e.g. see Figure 6), known in GT literature as semifricatives [4; 7]; these outputs have been included into the class of the fricatives, as they showed clear frication noise.

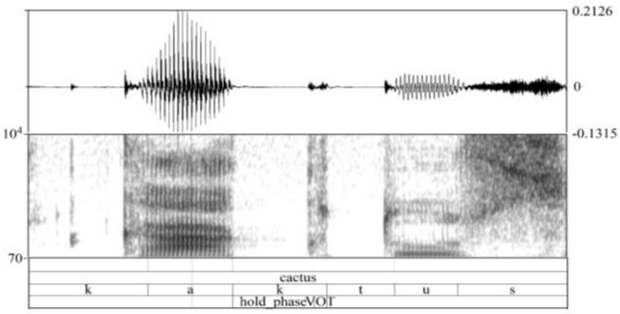

Figure 1: Soundwave and spectrogram of *cactus* [ˈkak.tus], female Florentine speaker, 58 years old.

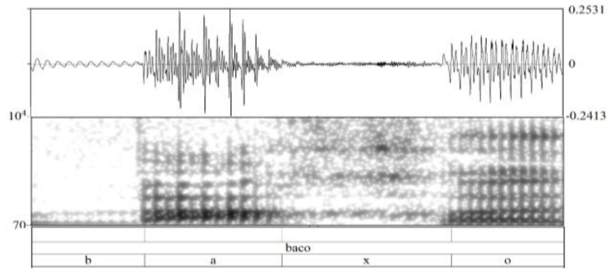

Figure 2: Soundwave and spectrogram of *baco* [ˈbaː.xo] "worm"; female Florentine speaker, 49 years old.

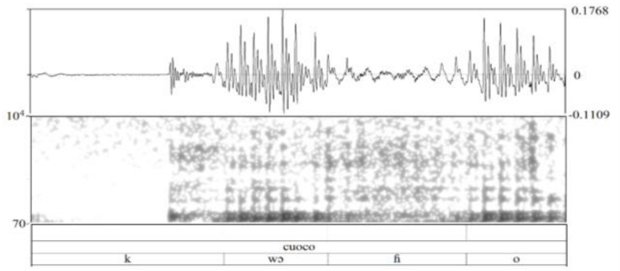

Figure 3: Soundwave and spectrogram of *cuoco* [ˈkwɔː.ɦo] "cook"; male Florentine speaker, 63 years old.

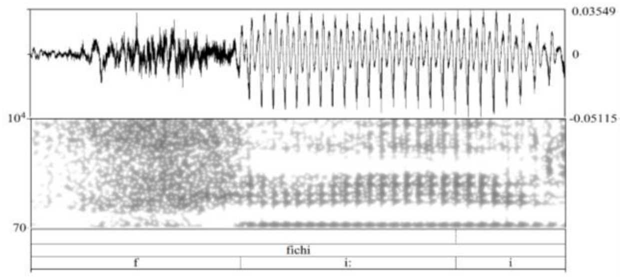

Figure 4: Soundwave and spectrogram of *fichi* [ˈfiː.i] "figs"; female Florentine speaker, 64 years old.

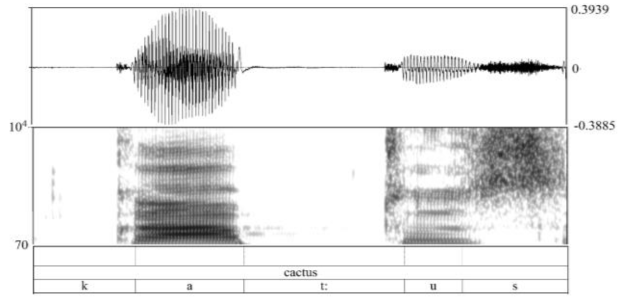

Figure 5: Soundwave and spectrogram of *cactus* "cactus" [ˈkat.tus]; female Florentine speaker, 48 years old.

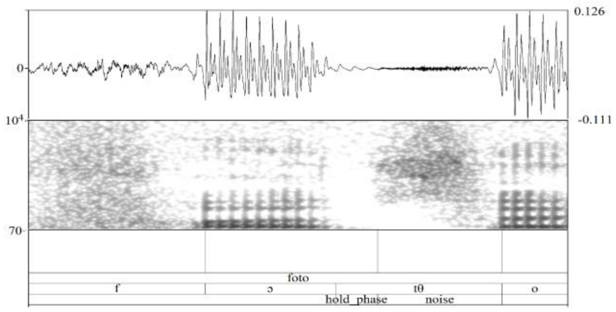

Figure 6: Soundwave and spectrogram of *foto* "photo" [ˈfɔː.tθo]; female Florentine speaker, 48 years old.

For each token, we measured phone duration (ms) and intensity (dB), two parameters that have been previously found correlating with stop lenition due to GT [4, 5].

3. RESULTS

The different surface outputs with their percentage values results are presented in Table 1. A clear-cut difference in the phonetic outputs of underlying voiceless plosives /p t k/ emerges with crucial reference to the syllable position of the target consonant.

	Stop	Fric	Approx	Delet	Assim
Onset	**20 (7%)**	**200 (69%)**	**61 (21%)**	**7 (2%)**	**0**
/k/	1 (1%)	41 (43%)	47 (49%)	7 (7%)	0
/t/	7 (7%)	86 (90%)	3 (3%)	0	0
/p/	12 (13%)	73 (76%)	11 (11%)	0	0
Coda	**167 (90%)**	**13 (7%)**	**0**	**0**	**6 (3%)**
/k/	65 (90%)	3 (4%)	0	0	4 (6%)
/t/	73 (88%)	9 (12,50%)	0	0	0
/p/	39 (93%)	1 (2%)	0	0	2 (5%)

Table 1: Phonetic outputs of /k t p/ with reference to syllable; Stop = stop, Fric = fricatives, Approx = approximants, Delet = deletion, Assim = assimilation.

Post-vocalic onsets are mostly lenited and surface as continuous segments, i.e. as fricatives and approximants (69% fricatives; 21% approximants; 90% in total). As previously observed in literature ([1] [2] [3]), the most affected segment by GT is the velar plosive /k/, which is even deleted in part of the tokens, with concomitant lengthening of the preceding vowel, like in [ˈfiːi] *fichi* "figs". In general, full closure articulations for post-vocalic onsets amount only to 7% of total tokens. On the contrary, segments in post-vocalic coda show the opposite trend, since 90% tokens show complete closure, whereas continuous segments are only 7% of total phonetic outputs. No approximants or segment deletions are found among the outputs occurring in coda position. Moreover, we observed that the few fricative outputs occur before nasals (/n m/; 8%), and sibilant (/s/; 13%; see Table 2), whereas before a following stop full regressive assimilation may occur, although quite rare (3%); typically /kt/ > [tː].

Acoustic measures relative to phone duration and intensity are in line with previous studies ([4; 5]; see Table 3). In onset position, going from stops and fricatives to approximants, a decrease in duration and an increase in intensity is observed, regardless of the place of articulation.

	Stop	Fric	Approx	Delet	Assim	Total
Coda	**167 (90%)**	**13 (7%)**	**0**	**0**	**6 (3%)**	**186 (100%)**
/C.N/	99 (92%)	9 (8%)	0	0	0	108 (100%)
./C.t/	42 88%	0	0	0	6 12%	48 (100%)
/C.s/	26 (87%)	4 (13%)	0	0	0,00%	30 (100%)

Table 2: Phonetic outputs of /k t p/ (C) in coda position with reference to the following segment; Stop = stop, Fric = fricatives, Approx. = approximants, Delet = deletion, Assim = assimilation

In coda position, a progressive decrease in duration is found going from stops to fricatives: the mean duration of the stops is 119 ms, whereas that of fricatives is 93 ms. The mean value of intensity in coda is similar for the two phonetic outputs: 46 dB for stops; 45 dB for fricatives; however, since only 13 tokens (7% of the outputs) are fricatives (see Table 1), a proper comparison is not possible. The comparison of the results of the acoustic analysis shows a longer duration of the segments in coda position compared to those in onset position. In particular, coda stops are 40 ms longer than onset stops and coda fricatives are 20 ms longer than onset fricatives. The intensity shows similar values for stops and fricatives in both contexts (from 45 to 48 dB), whilst the approximant outputs are louder (58 dB on average).

		Stop Mean (sd)	Fric Mean (sd)	Appr Mean (sd)
Onset				
	Duration (ms)	**82 (11)**	**77 (17)**	**51 (18)**
	Intensity (dB)	**47 (9)**	**48 (6)**	**58 (6)**
/k/	Duration (ms)	84	77 (18)	50 (19)
	Intensity (db)	45	48 (6)	60 (5)
/t/	Duration (ms)	77 (11)	76 (18)	62 (8)
	Intensity (dB)	46 (5)	48 (6)	51 (4)
/p/	Duration (ms)	85 (10)	77 (14)	54 (9)
	Intensity (db)	47 (11)	49 (7)	53 (6)
Coda				
	Duration (ms)	**118 (35)**	**93 (23)**	
	Intensity (dB)	**46 (8)**	**45 (5)**	
/k/	Duration (ms)	119 (45)	78 (18)	
	Intensity (dB)	45 (6)	43 (4)	
/t/	Duration (ms)	125 (30)	102 (19)	
	Intensity (dB)	45 (8)	45 (4)	
/p/	Duration (ms)	106 (20)	56	
	Intensity (dB)	48 (9)	53	

Table 3: Duration and intensity (mean and standard deviation) of phonetic outputs with reference to syllable position and place of articulation; Stop = stop, Fric = fricatives, Approx = approximants.

We fitted a linear mixed model created with the R (version 4.3.0) [13] function *lmer()* of the package *lme4* [14] to test if the syllable position interacts with the manner of articulation, interpreted as continuous (i.e. fricatives, approximants and deletion) and non-continuous (i.e. stops). Speaker, gender, word, and place of articulation were set as random effects. The results show that the effect of the syllable constituent (onset vs. coda) is statistically significant ($\chi^2 = 63{,}7$, $p < 0.001$). Therefore, our study provides further evidence in favour of the syllable constraint on GT.

4. DISCUSSION

GT is traditionally described as a phenomenon affecting intervocalic stops, especially if voiceless ([1; 2; 3]). However, since GT applies also before liquid consonants and glides (cf. § 1. Introduction), the context of application of GT is best described as postvocalic ([4; 7]). With reference to syllable structure (see [15; 16]), GT can be interpreted as a lenition process affecting any postvocalic stop segment associated with the onset constituent. If this interpretation is correct, it follows that a stop in coda position does not undergo GT. In order to verify such prediction, we investigated the acoustic output of voiceless stops in coda position produced by Florentine speakers. The results collected show that stops in this context are not a target for GT, thus confirming the hypothesis that GT affects stop segments only if associated to the onset position.

However, we also found some fricative outputs when the stop is followed by a nasal consonant or /s/. These data seem to be compatible with a possible tautosyllabic interpretation of the clusters stop + *s* or *n, m*, i.e. as complex onsets. Indeed, such clusters obey the *Sequencing Sonority Principle* ([8]), being the second segment weaker than the preceding one; in parallel, the degree of sonority increases from the plosive consonant to the nasal as well as to the sibilant. Moreover, this view agrees with the data concerning the selection of the definite article in Italian [17]: before words beginning with the clusters stop + *s* or *n, m* Tuscan speakers optionally select the allomorph *il*; e.g. *il psicologo* “the psychologist”, *il pneumatico* “the tire”, unlike standard Italian where the allomorph *lo* is preferred. The allomorph *il* usually occurs before onsets, both simple and complex (i.e. branching), both in Standard Italian and Tuscan varieties; e.g. *il ponte* “the bridge”, *il prato* “the meadow”, *il toro* “the bull”, *il treno* “the train”.

In conclusion, our study is the first one investigating the phonetic output of stops in the context of syllable coda in Tuscan Italian. The results collected show that stops in coda do not lenite, except in a few cases. Although the data are consistent and statistically significant, we believe that further studies are needed to verify the consistency of our empirical data. We planned to extend the analysis to a larger sample of speakers as well as to other areas of Tuscany.

The data presented highlight the relevance of the syllable structure in the process of Tuscan lenition. Three conditions must be satisfied in order for GT to apply. Firstly, the target segment has to be a stop. Secondly, the stop must be preceded by a vocalic segment (vowel or glide), since after a consonant GT does not apply. Thirdly, the stop has to be associated with the syllabic onset position; more precisely, the segment needs to be the head of an onset, since we know that the first segment of a *muta cum liquida* is also affected by lenition, mirroring simple onset contexts (e.g. [ˈlaːxrima] *lacrima* “tear”, [ˈliːθro] *litro* “liter”, [ˈkaːɸra] *capra* “goat”). The occurrence of a lenition process in syllabic onsets is not surprising; as a matter of fact, many languages show similar phenomena in the same context. In particular, lenition is a well-documented process in Romance languages (see for instance [18]).

On the other hand, coda position is traditionally considered a weak context although segments in syllable coda are affected by different weakening processes as compared to onsets ([19]). We might expect plosives to become spirants in coda position too, via GT. As this is not the case, it is possible that Tuscan speakers preserve stops in coda position because of the constraints of their native lexicon that do not allow lenition in this context. GT is a phonological process acting on the native lexicon which may not apply to new items belonging to peripheral or more recent areas of the lexicon. However, even though recent loanwords were not analysed in this study, our corpus also includes some English loans recently entered in the lexical competence of Italian speakers including a postvocalic onset (e.g. *meeting*, *Microsoft*).

According to a preliminary analysis, it appears that GT regularly applies also to these items, if the conditions are met (e.g. [ˈmai̯xrosoft] *Microsoft*, [ˈmiːθiŋg] *meeting*). It is also possible that the particular kind of data elicitation we adopted (i.e. reading) influenced the participants, encouraging a more standard production, with stricter corre-spondence to the orthographic input. Future investigations will also be aimed at analysing spontaneous speech, in order to verify the hypotheses advanced here with the support of more exhaustive data.

5. REFERENCES

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