Towards a sociophonetic explanation of anticipatory and perseverative assimilation in Italian nasal+stop clusters

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Abstract

Different patterns of place and manner assimilation in nasal+stop clusters in terms of different timing relationships between segments are investigated. The existence of strict internal balance conditions within the cluster is hypothesized and evaluated with respect to Italo-Romance dialectological data. The role of speech rate variation is also analyzed. Drawing together laboratory research and geolinguistic analysis of nasal allophones distribution, the present study aims at shedding light on the determinants of anticipatory and perseverative assimilation processes in homorganic nasal+stop clusters.

1. Introduction

1.1. Geolinguistic perspectives within the Romance domain

It is well known that nasal+stop clusters tend to be homorganic, since the nasal stop frequently assimilates for place to the following oral stop (see [1], p. 178; [2], [3] for (Italo-)Romance varieties). As for place of articulation, nasals are notoriously the target of an anticipatory assimilation. Nasals generally undergo the effect of postnasal and not *vice versa* (It. /ˈanke/ 'also': [ˈaŋke] and not *[ˈante]), being the opposite strategy virtually unattested ([4], p. 199). The pervasiveness of anticipatory nasal place assimilation appears to be in agreement with a fundamental tendency of coarticulation, being anticipatory assimilations more frequent than perseverative ones (e.g. [4], [5]).

Nevertheless, the nasal can also alter the articulation of the postnasal in at least two ways, as documented in many varieties of the Italo-Romance area. First, laryngeal assimilations in nasal+stop clusters tend to be perseverative. Voiceless post-nasals voice in some central and southern Italian dialects, "a sud di una linea che va dai Monti Albani fino ad Ancona attraverso l'Umbria" ([2], § 254): e.g., *dende* 'tooth' (It. *dente*), *cambo* 'field' (It. *campo*), *biango* 'white' (It. *bianco*). Second, complete assimilations of homorganic clusters are also left-to-right: in some southern Italian dialects, voiced post-nasals assimilate to nasals (e.g., *munno* 'world' for It. *mondo*, *piommo* 'lead' for It. *piombo*, *mmidia* 'envy' for It. *invidia*, [ˈliŋwa] 'tongue' for It. *lingua*). According to [6], this kind of assimilation also appears in some Alpine varieties of Alto Adige and in parts of central-southern Sardinia.

Both laryngeal and complete assimilations are generally believed to function as sociolinguistic variables in conveying the speaker's socio-cultural and geographical identity. Complete assimilations seem to be statistically more frequent when the postnasal is a coronal consonant. Within the Italo-Romance domain, complete assimilations of etymological /nt/, /nd/ clusters shows a larger geographical extension if compared to assimilation in /nk/, /ng/ clusters. This is particularly evident if one considers the farthest south of Italy, where only limited areas of Sicily, Calabria, Lucania and Salento (according to [2], § 255, [6], [7], [8]) show complete assimilation of /ng/ clusters (see Fig. 1, based on AIS tables no. 88 and no. 106 [9]). The origin of this sound change is said to be analogical with respect to complete assimilation in /nd/ clusters. Considering the lack of written evidence, it is impossible to ascertain whether this spotted distribution is the consequence of local independent evolution, or a vestige of a larger territory that was homogeneously affected by the process in the past. Systematic studies on this topic are still lacking [10].

Figure 1: *Geographical distribution of complete assimilation in /n/+alveolar (yellow areas) and /n/+velar stop clusters (blue circles) in Italo-Romance.*

1.2. Phonetic issues

Some authors have suggested that nasal clusters undergo different coarticulatory processes depending on whether the post-nasal consonant is voiced or voiceless (e.g., [11] and references therein). In particular, post-nasal consonants tend to totally assimilate to nasals when voiced, giving rise to a geminate nasal; on the other hand, nasal weakening/loss or anticipatory assimilations are frequently observed in clusters with voiceless post-nasals. Cross-linguistic evidence is frequently reported on this subject, testifying that this assimilatory pattern is visible not only within the Romance domain, but also for other I.E. languages, such as Old Norse: compare e.g., *finðan > *finna* 'to find', *munða > *munnr* 'mounth' with *klettr* 'rock' (Swedish *klinter*), *brekka* 'brink'. In [11] an explicit statement on the phonetic basis of anticipatory *vs* perseverative assimilations is made: the discrepancy between nasal 'dominance', on one hand (such as in Neap. *munnə* 'world'), and different degrees of nasal assimilation or weakening, on the other hand (such as in Ital. *ba[ŋ]ka* or Old Norse *brekka* 'brink') would lie in the articulatory difference between pre-voiced and pre-voiceless nasals, the former being *longer* than the latter. For example, in Spanish and English there is a tendency for nasals to be longer when followed by voiced stops (see experimental data in [11]). Although the author does not explicitly comment on this, the temporal pattern of nasal consonants appears to be balanced by an inverse effect on the duration of the postnasal consonant, voiceless consonants being longer than the corresponding voiced cognates. The different treatment of clusters with voiceless and voiced stops has been described not only in historical linguistics but also in language acquisition, and has been said to be a universal tendency of "feature interaction" in [1]. [4] points out that the complete assimilation of obstruents to sonorants is a relatively marked phenomenon, compared to laryngeal assimilations. The same explanation has been put forward also in the case of voicing of the postnasal stop [1] and this perspective accounts also for the anticipatory assimilations attested outside the Romance and I.E. domain whereby nasals share the voicing category of the following stop [12].

2. Experimental design

2.1. Aims of the experiment

In the light of the dialectological and phonetic data reviewed above, the following hypotheses can be put forth with respect to anticipatory and perseverative assimilation in nasal+stop clusters.

First, there seems to be a different temporal behavior of nasals according to the nature of the following consonant (whether this is voiceless or voiced). The available phonetic data discussed in § 1.2 are only indirectly focused on the possible relation between segments' duration and assimilatory outcomes. Informal observations on the existence of balancing relations within the cluster were indeed present in the previous literature. The different temporal behaviour of nasals according to the nature of the following consonant should therefore be investigated in terms of *relative timing* of segments within the clusters. In order for a nasal to 'dominate' before voiced consonant and to be 'lenited' before voiceless consonant, the nasal-to-postnasal duration ratio should be higher in voiced clusters than in voiceless clusters. The relative timing of segmental units within the cluster, rather than the nasal temporal patterns exclusively, can therefore be analyzed in order to test the validity of this articulatory explanation for the above mentioned sound changes. Second, geolinguistic considerations on the Italo-Romance domain suggest that there should be a preference for nasal+alveolar stop clusters to undergo complete assimilation, with respect to nasal+velar stop clusters. It can therefore be hypothesized that the place of articulation of the post-nasal consonant has an influence on the timing relations within the nasal+stop clusters, thus providing a phonetic explanation for the existence of partially divergent pattern of place assimilations in /nk/, /ng/ as opposed to /nt/, /nd/ clusters.

Third, it has to be noted that the dialectological and cross-linguistic literature reviewed in §§ 1.1 and 1.2 does not include stylistic factors as a possible source of variation in nasal place assimilation patterns. Indeed nasal place assimilations, like many other types of assimilation, may be seen as determined by physiological constraints on speech production [13]. Moreover, it has extensively be shown that many cases of place assimilation in /n(#)k/ or /n(#)p/ contexts are graded phenomena and leave some residual alveolar gesture alongside the velar or bilabial closure [14]. For these reasons, assimilations in nasal clusters are supposed to be sensitive to variations in speech rate: increased rates of speaking should create conditions that favor assimilations. The role of speech rate variations in coarticulation processes is clearly stated by [13]: increased rates of speaking have demonstrable effects on the mechanics of articulators and on the relative organization of speech gestures (i.e., on change initiation); at the same time, these effects "could be voluntarily overridden by the speaker, who could increase his articulatory explicitness", thus influencing the transmission of change in a non-deterministic manner. Therefore, speech rate manipulations allow the researcher to investigate the degree of gestural reorganization due to temporal compression; on the other hand, speech rate variations are also a window on stylistic variations, thus providing indirect evidence on one of the most relevant sociophonetic dimensions of sound change.

To summarize, the present investigation aims at replicating in an experimental setting the conditions of a group of sound changes showing clear sociophonetic implications in some Italo-Romance areas (i.e., /nt/ > /nd/ > /nn/, /nk/ > /ŋk/ > /ŋŋ/, /ŋk/ > /ŋg/). We expect that different types of assimilation originate from different conditions in the relative timing among sounds in sequences varying for place and voicing of the postnasal consonant, and in particular: the duration ratio between the nasal and the post-nasal consonant should be higher in clusters with voiced compared to clusters with voiceless post-nasal. Moreover, given the external evidence reviewed above, we hypothesize that in nasal+alveolar stop clusters the temporal reduction of pre-voiceless nasals (with respect to pre-voiced nasals) should be more consistent than in nasal+velar clusters, thus accounting for the preference for nasal+alveolar stop clusters to undergo complete assimilation. Finally, we wanted to verify whether the temporal relationship among sounds in /nC/ clusters is consistent across different rates of speech or, rather, varies according to the hypothesis that temporal reductions involved in nasal place assimilations are coarticulatory processes favored in fast speech, with respect to other styles.

2.2. Materials, subjects, methods

Sixteen meaningful Italian words containing a nasal+alveolar or a nasal+velar stop cluster were embedded in short isosyllabic frame sentences. The postnasal stop could either be voiced (/nd/, /ng/) or voiceless (/nt/, /nk/). Target words had been selected in order to preserve an invariable vowel context (/ˈanCa/); stress was always on the vowel preceding the /nC/ cluster. Examples of target words are *mancano* /ˈmaŋkano/ '(they) are lacking', *vangano* /ˈvaŋgano/ '(they) spade', *cantano* /ˈkantano/ '(they) sing', *mandano* /ˈmandano/ '(they) send'. Four native Italian speakers with no reported speech, language or hearing pathology, aged 30-35, speaking a Tuscan variety of Italian were recorded separately in an anechoic chamber. The recording session could last between 90 an 120 minutes for each participant. The experimental sentences were randomized and the participants were asked to produce 30 repetitions of each sentence, at a normal, slow and fast rate of speaking. For the elicitation of normal speech, the target sentences were preceded by contextual questions. For slow speech, the subjects were asked to produce clear uttered sentences as if they were speaking to non-native listeners. For fast speech, they were asked to increase their rate of speaking but avoid clipping of syllables or single sounds.

The duration (in msec) of each sentence, /ˈanCa/ sequence and /nC/ clusters was measured. For each cluster, the duration of the nasal and that of the postnasal consonant (closure phase) was measured; on that basis, the nasal-to-postnasal duration ratio for each cluster was calculated. Those repetitions in which the cluster was not realized as completely homorganic were excluded from the analysis. The factors of the analysis were speaking rate (normal, fast, slow), place of articulation of the postnasal consonant (alveolar, velar) and its laryngeal status (voiceless, voiced).

3. Results and discussion

In the present investigation, we performed an acoustic analysis of the stimuli and concentrated on segments' (relative) durations. The results summarized in this section are therefore preliminary inasmuch as an articulatory-cinematic analysis of the speakers' production will follow; evidence from that domain will be more conclusive with respect to the timing of gestures involved in the realization of nasal+stop clusters.

3.1. Speech rate variation

First, we wanted to verify whether the speaking instructions were appropriate to induce the speakers to read the sentences at three different rates. To that aim, we measured the duration of each sentence and compared the three stylistic conditions in the speech of each subject separately. The three speech rates turned out to be significantly different from one another for sentence duration in the speech of all the speakers (the duration of the sentence in fast, normal and slow speech was 971 ms, 1.223 ms and 2.026 ms, respectively, for subject A; 900 ms, 1.166 ms and 1.560 ms for subject B; 1.004 ms, 1.186 ms and 1.738 ms for subject C; 922 ms, 1.309 ms and 1.741 ms for subject D; in all cases, p=.000). This confirmed that the subjects had been successful in the task of producing three different speech styles. The same difference was observed when the productions of the fours subjects were grouped together (F(2,941)=1491.4; p=.000), thus indicating that no idiosyncrasies were present in the data with respect to one or some of the subjects. In order to verify whether speech rate variations were observable even in the case of constituents smaller than the sentence, we compared the duration of /anCa/ sequences and nasal+stop clusters as produced in the slow, normal and fast speech. The three elicited styles turned out to be significantly different from one another even in the case of these small constituents (F(2,941)=1534.14, p=.000 for /anCa/; F(2,941)=1808.21, p=.000 for /nC/ sequences).

3.2. Timing in nasal+stop clusters

With respect to absolute durations, nasal+stop clusters turned out to be overall longer when the postnasal consonant was voiceless (/t/, /k/) than when it was voiced (/d/, /g/) (see Table 1). This effect was consistent across speech styles, and for both alveolar and velar clusters. On the other hand, the clusters did not differ significantly according to the place of articulation of the postnasal consonant, thus indicating that, from the point of view of total duration, velar and alveolar clusters were not distinguishable.

The analysis of the nasal-to-postnasal duration ratio showed that a cluster internal balance was consistently realized across speech styles and places of articulation. The three-way interaction rate*place*voicing was found to be highly significant (F(11,941)=208.58, p<.005), thus indicating that segments' timing within the cluster differed according to the voicing characteristics of the postnasal consonant, and that both speech style and place of articulation of the postnasal had an influence on this effect. Figure 2 shows the ratio values for the relevant clusters in the different experimental conditions. The portion of the cluster occupied by the nasal consonant turned out to be consistently greater in the case of pre-voiced nasals, as shown by higher nasal-to-postnasal duration ratios in /nd/ and /ng/ clusters, compared to /nt/ and /nk/. The effect of postnasal voicing on the temporal structure of the cluster is a very strong one. This result therefore confirms that the nasal durational patterns are to be seen as one of the effects of the complex timing relations holding among segments in the cluster: voiced postnasals are preceded by longer nasals, voiceless postnasals are preceded by shorter postnasal. This effect was also totally independent from the absolute durations of alveolar *vs* velar clusters, which were not distinguishable overall (see above).

	Fast	Normal	Slow
voiceless	0.112	0.136	0.212
voiced	0.089	0.104	0.174
p	.000	.000	.000

Table 1: */nC/ cluster average duration values (in msec) split by speech rate and voicing of the postnasal consonant.*

With respect to the role of speech rate and place of articulation of the postnasal consonant, two separate two-way interactions were run. The statistically significant rate*voicing interaction (F(5,941)=11.816; p=.000) revealed that the cluster internal balance effect was in part dependent on speech rate variations. In particular, it is in the slow speech of the speakers that the difference between the duration ratios according to the voicing of the postnasal is stronger, compared to the values attested in normal and fast speech (see Table 2). Pre-voiced nasals appear to be extensively lengthened in slow speech, giving rise to a condition where the nasal occupies more than twice the portion of the postnasal consonant in the cluster. However, pre-voiced nasal lengthening is partly mirrored by a tendency to pre-voiceless lengthening in slow speech as well (compare the 0.56 ratio value for slow speech with the 0.40 and 0.45 values for fast and normal speech). This data are likely to be interpretable in terms of a general lengthening that affects particularly continuant segments (and nasals among them) in the slow speech of the speakers. In fact, articulation rate variation is not a simple horizontal time compression or expansion of acoustic intervals corresponding to consonant or vowel: at slow tempo, continuant segments tend to stretch more than obstruents and contribute more to increased overall word duration. On the contrary, the normal and fast speech closely resemble each other in showing 1.6-1.7 ratio values for the voiced clusters and 0.40-0.45 for the voiceless clusters.

In the light of this evidence, we can provisionally conclude that the temporal compensation between segments in the cluster seems to be unaffected by gestural shortening and reduction as realized in fast speech; the timing relations that differentiate clusters with voiced from clusters with voiceless postnasals are kept constant when speech rate increases, compared to normal speaking conditions.

With respect to the role of place of articulation, the place*voicing interaction was found to be statistically significant (F(3,941)=11.910; p<.005), thus indicating that the voicing effect had a different magnitude in clusters composed of velar consonants, with respect to those composed by alveolars. In particular, the difference in the duration ratios according to the voicing of the postnasal appeared to be greater for clusters with alveolar than for clusters with velar consonants (Table 3), proving that pre-voiced nasal lengthening is more evident when an alveolar stop follows, than when a velar stop follows. These results might explain the tendency for alveolar clusters to undergo total assimilation more often and more extensively than velar clusters do, as documented by historical changes as well as sociophonetic alternations in southern Italian varieties.

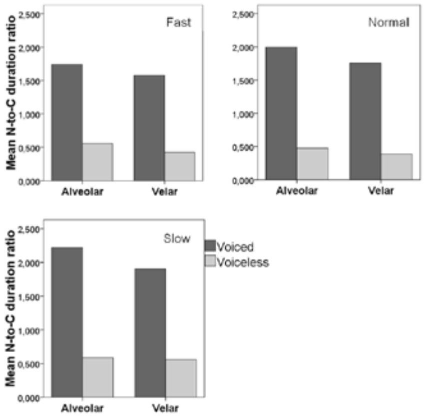

Figure 2: *Nasal-to-postnasal duration ratios split by place and voicing of the postnasal consonant.*

	Fast	Normal	Slow
voiceless	0.45	0.40	0.56
voiced	1.59	1.70	2.06

Table 2: *Nasal-to-postnasal duration ratios split by speech rate and voicing of the postnasal consonant.*

	Fast		Normal		Slow		Total	
	alv	vel	alv	vel	alv	vel	alv	vel
voiced	1.74	1.61	1.90	1.53	2.14	1.92	1.94	1.67
voiceless	0.57	0.44	0.44	0.39	0.56	0.60	0.52	0.48

Table 3: *Nasal-to-postnasal duration ratios split by place of articulation and voicing of the postnasal consonant.*

4. Conclusions

Previous studies had pointed to the existence of different routes of assimilation for nasal+stop clusters depending of the voicing characteristics of the postnasal consonant, clusters with voiced consonants being more prone to total perseverative assimilation and clusters with voiceless consonants tending to undergo nasal weakening and loss (§ 1.1). It has been stated that, at least in the Romance domain, pre-voiced nasals are longer than pre-voiceless nasals, and for this reason they are more susceptible of spreading their features onwards to the following segment (§ 1.2).

In the present study, what had been sporadically observed by previous authors in terms of different durational patterns of pre-consonantal nasals, has been systematically confirmed in terms of cluster internal timing relations. Our data support the hypothesis that nasals occupy a larger portion of the cluster when followed by voiced stops, than when followed by voiceless stops. The data also promote the view that such difference in cluster intrinsic timing depending on the laryngeal specification of the postnasal consonant is likely to be a universal of speech production, being consistently produced by the speakers not only in the 'normal' conditions of speaking, but also when speech articulation is modified in terms of both increased and reduced speech rate.

The comparison between alveolar and velar clusters proved that also place of articulation plays a role. Pre-voiced nasal lengthening was found to be stronger in alveolar than in velar clusters. This finding is relevant from an historical and geolinguistic point of view: the preference for total perseverative assimilations in alveolar clusters, as attested in diachronic, geographical and sociolinguistic variation of southern Italian dialects, could be explained in terms of articulatory constraints favoring 'nasal dominance' in coronal clusters.

By varying the parameter of speech rate it has been demonstrated that the complexity of nasal cluster assimilation cannot be reduced to aspects of connected speech. Increased rates of speaking did not create conditions favoring assimilations: on the contrary, it was perhaps in the slow speech of our subjects that the voicing effect appeared to be stronger, due to increased lengthening of pre-voiced nasals compared to pre-voiceless nasal. Temporal expansions may therefore involve processes of gestural restructuring that are idiosyncratic with respect to both normal and fast speech.

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6. References

[1] Ferguson C.A. 1975. Universal tendencies and 'normal' nasality. In Ferguson C.A., L.M. Hyman and J.J. Ohala (eds). *Nasálfest. Papers from a symposium on nasals and nasalization*. Stanford: Stanford University Press. 175-196.

[2] Rohlfs G. 1966. *Grammatica storica della lingua italiana e dei suoi dialetti. Fonetica*. Torino: Einaudi.

[3] Maiden M. and M. Parry 1997 (eds.). *The dialects of Italy*. London/New York: Routledge.

[4] Lass R. 1984. *Phonology. An introduction to basic concepts*. Cambridge: Cambridge University Press.

[5] Bybee J. and S. Easterday. 2010. Gestures in sound change: anticipatory vs. perseverative assimilation. Poster presented at *12th Conference on Laboratory Phonology*. Albuquerque (NM), 8-10 July 2010.

[6] Savoia L.M. 1997. The geographical distribution of the dialects. In Maiden M. and M. Parry (eds.). *The dialects of Italy*. London/New York: Routledge. 225-234.

[7] Loporcaro M. 1997. Puglia and Salento. In Maiden M. and M. Parry (eds.). *The dialects of Italy*. London/New York: Routledge. 338-348.

[8] Trumper J. 1997. Calabria and southern Basilicata. In Maiden M. and M. Parry (eds.). *The dialects of Italy*. London/New York: Routledge. 355-364.

[9] Jaberg K. and J. Jud. 1928-40. *Sprach- und Sachatlas Italiens und der Südschweiz.* Zofingen: Ringier & Co. Available at www.navigais.it (NavigAIS by G. Tisato).

[10] Caracausi G. 1986. *Lingue in contatto nell'estremo mezzogiorno d'Italia. Influssi e conflitti fonetici*. Palermo: CSFLS.

[11] Tuttle E.F. 1991. Nasalization in Northern Italy: syllabic constraints and strength scales as developmental parameters. *Italian Journal of Linguistics* 3. 23-92.

[12] Ladefoged P. and I. Maddieson. 1996. *The sounds of the world's languages*. Oxford: Blackwell.

[13] Nolan F. and P.E. Kerswill. 1990. The description of connected speech processes. In Ramsaran S. (ed.). *Studies in the pronunciation of English.* London: Routledge. 295-316.

[14] Nolan F. 1992. The descriptive role of segments: Evidence from assimilation. In Ladd D.R. and G. Docherty (eds.), *Laboratory Phonology II*. Cambridge: Cambridge University Press. 261-280.