COARTICULATORY TIMING AND AERODYNAMICS OF NASALS AND NASALIZATION

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ABSTRACT

This paper discusses Beddor, Shosted and Solé papers that deal with the relation between segmental and coarticulatory timing for nasals and nasalization; the aerodynamics of nasalized fricatives and the compatibility and phonetic content of features in the case of nasalization. Three points are discussed: (i) the hypothesis of a constant size of velum gesture; (ii) nasalized fricatives and (iii) nasalization in manner features and voicing.

Keywords: coarticulatory timing, velum gesture, nasalized fricatives, nasalization.

1. INTRODUCTION

The three papers discussed deal with (among other things) aspects of coarticulation of nasals and nasalization. Beddor's hypothesis that some aspects of variable vowel nasalization are due to variation in the temporal alignment of nasal and oral gestures for nasals (N) will be discussed in the light of data from Rwanda, a language that allows discussing the interplay between vowel nasalization and N duration. This language was chosen because it differs in the segmental contexts in which VN sequences occur compared to English, Ikalanga and Thai. The focus will be the hypothesis that there is a roughly constant nasal gesture relative to oral closure in the first member of VNC comparisons.

Shosted's results demonstrate that nasalized fricatives are phonetic possibilities in natural speech will be discussed in the light of data from Umbundu. In addition the discussion that one possible source of nasalization in fricatives is their proximity to nasals segments will be discussed also from Rwanda data.

Solé's discussion on the compatibility of features and phonetic content in the case of nasalization will be discussed with some data from Rwanda and Karitiana. The main focus will be on the interaction between nasality and voicing in consecutive segments. Solé illustrates this point with the case of Japanese. The discussion will focus on the alternations between voiceless stops and prenasalized voiced stops and languages where stops are phonetically prenasalized.

2. CONSTANT SIZE VELUM GESTURE

The hypothesis that some aspects of variable vowel nasalization are due to variation in the temporal alignment of nasal and oral gestures can be discussed by observing data from Rwanda. This language has a large set of prenasalized obstruents. According to Jouannet [1] Rwanda has three groups of prenasalized stops in its phonetic inventory: (i) a set of voiced and voiceless prenasalized stops [mh, mb, mf, mv, nh, nd, ns, nz, nʃ, nʒ, ng, ŋh, ŋg]; (ii) a set of voiced and voiceless labiovelarized prenasalized stops [mbg, mvg, ndgw, nzgw, nʒgw, ŋgw, m̥hn̥, n̥hŋ̊w, nskw, nʃkw, ŋ̊hw] and (iii) a set of voiced and voiceless palatalized prenasalized stops [mpfy, mbɟ, n̥hn̥, ndɟ, nstʃ, n̥hy, ŋɟ].

Beddor shows that Ikalanga shows no influence of voicing on nasalization. In this language, as in other Bantu languages such as Rwanda, NC sequences are traditionally analyzed as prenasalized ^{N}C. Most VNCV's in Ikalanga are voiced although some $NC_{[voiceless]}$ occur (Mathangwane [2]). As Rwanda has a rich set of voiceless prenasalized obstruents it is therefore interesting to see if the timing pattern observed in Ikalanga is similar for Rwanda or if it patterns with Beddor's observations made in English and if the relatively constant–sized nasal gesture across VNCV (and NCV) is also observed in this language.

2.1. Measurements

Aerodynamic recordings (intraoral Ps, oral and nasal airflows) were made using the Physiologia workstation (Teston and Galindo [3]) linked to a data collection system equipped with different transducers.

Acoustic recordings were made with the same material via a High Fidelity microphone set on the hardware piece of equipment connecting the transducers to the computer.

Spectrograms and audio waveforms were processed with the *signal explorer* software.

Seven speakers of Rwanda (6 women and one man) were recorded reading a word list targeting prenasalized sequences. They were asked to read the words containing in a small carrying sentence vuga__itʃumi, 'say__ten times'. Table 1 shows the data analyzed for this paper.

Acoustic measures included vowel duration, duration of vowel nasalization, nasal consonant duration and duration of flanking oral consonants. Acoustic onset of the vowel nasalization was determined in a way similar to Beddor. Aerodynamic measurements included duration of oral and nasal airflow during vowels and nasal consonants.

Table 1: Rwanda data analyzed in this paper (tones omitted).

imhamba *food*	inʃuti *friend*
imbaraga *strength*	iŋha *cow*
imfiizi *bull*	iŋgaɟi *gorilla*
inzu *house*	insina *banana tree*
inhama *sip*	inʒiʒi *fool*
inda *belly*	imvura *rain*

2.2. Effect of temporal voicing on temporal alignment

The temporal measures described in Beddor were applied to VNC sequences produced by speakers of Rwanda to determine whether shortening of pre-voiceless N occurs and, if so, whether N shortening of pre-voiceless N co-occurs with greater vowel nasalization. The goal was to determine whether the schematic relation described by Beddor between the VNC (voiced and voiceless) is upheld in Rwanda. In addition aerodynamic measurements of oral and nasal airflow were used to estimate the size of the velum gesture and to see if in comparable environments there is a constant-sized velum gesture.

2.3. Results

Results of the measurements made in Rwanda show that there is a tendency for vowels to have greater nasalization in $VNC_{[voiceless]}$ compared to sequences where the consonant is voiced. The size of the velum gesture is comparable but before fricatives where it is shorter before voiced and longer before voiceless fricatives. This is illustrated in Table 2.

Table 2: Durations of oral and nasalized portions of vowels, and of nasal and oral consonants in VNCV sequences in Rwanda averaged across productions of 7 speakers (n=14 for sequence).

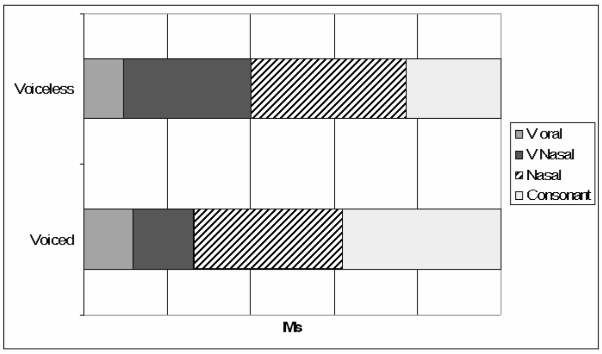


Figure 1: Spectrogram and aerodynamic parameters [Ps (Pio), Oral and nasal airflow (AFo & AFn)] of the word inzu 'house' in Rwanda. The first arrow shows the measurement place for the velum opening. The double arrow shows the limit between the nasal and the following fricative.

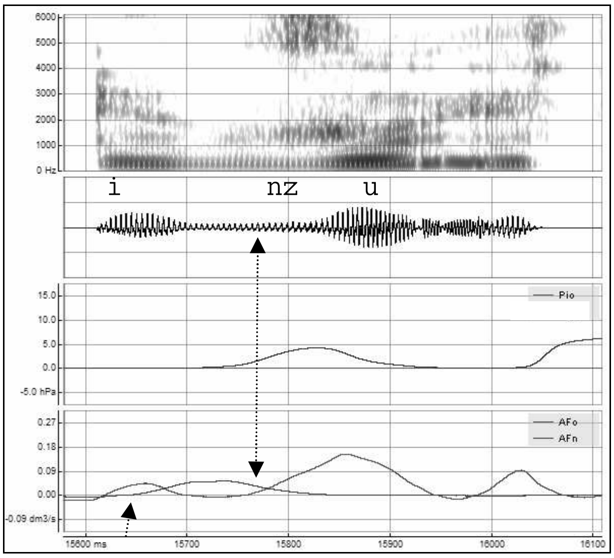
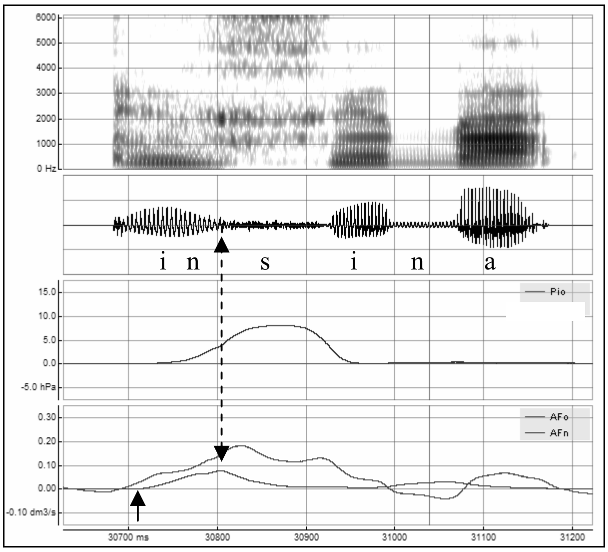


Figure 2: Spectrogram and aerodynamic parameters [Ps (Pio), Oral and nasal airflow (AFo & AFn)] of the word insina 'banana tree' in Rwanda. The first arrow shows the measurement place for the velum opening. The double arrow shows the limit between the nasal and the following fricative.



3. NASALIZED FRICATIVES

3.1. Umbundu

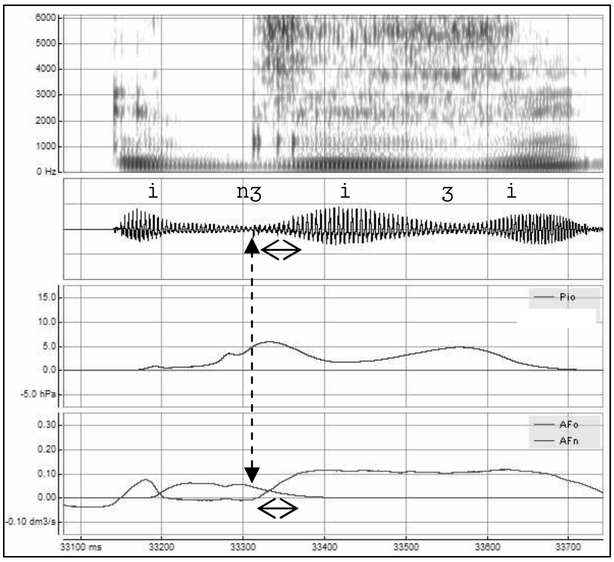
Shadeberg [4] has argued for the existence of nasalized [ṽ] in Umbundu sparking some debate (e.g. Ohala and Ohala [5]). Shosted [6] shows how the geometry of the vocal tract and aerodynamic constraints make the existence of nasalized fricatives problematic but not impossible. For perceptive and aerodynamic reasons [v] is the fricative most likely to combine with nasalization.

Schadeberg also claims that nasalized continuants require "considerable articulatory effort" vis-à-vis nasal stops. According to him, this explains why nasalization spreads from the former but not the latter. Shosted [6] showed that the increased "ariculatory effort" that is either transglottal flow or velopharyngal aperture is not a reasonable explanation for nasal prosodies conditioned by nasal fricatives, since more flow would extinguish voicing and more nasalization would extinguish frication. Shosted then suggests that the timing of the velopharyngal opening is adjusted to increase the percept of nasalization of preceding vowels.

3.2. Nasalization spreading

Shosted's results demonstrate that nasalized fricatives are phonetic possibilities in natural speech. One possible source of nasalization in fricatives is their proximity to nasal consonants. As Shosted has shown, it is possible for air to pass through the nose and the mouth while a speaker is uttering a phonemically oral fricative. This can be seen in Figure 3 that shows that the nasal consonant gesture spreads into the following voiced palatal fricative.

Figure 3: Spectrogram and aerodynamic parameters [Ps (Pio) , Oral and nasal airflow (AFo & AFn)] of the word inʒiʒi 'fool' in Rwanda. Arrows indicates the frontier between the nasal and the fricative and the duration of the fricative.



The example of Figure 3 shows that even if the velum is in a closing phase, there is some nasal airflow spreading into the voiced fricative that follows the nasal. Note also that this observation goes along Solé's claims that nasalization favors voicing. Indeed no example of the Rwanda data that has voiceless fricatives preceded by nasals shows comparable spreading. This early onset of the velum gesture in $VNC_{[voiceless]}$ is probably a manifestation of the resistance of voiceless stops to 'nasal leakage' [5].

4. NASALIZATION MANNER FEATURES AND VOICING

The discussion made by Solé on the alternations between voiceless stops and prenasalized voiced stops is substantiated by data from Maddieson's UPSID database [7] and observations made in languages that are not reported in this inventory such as Mangbetu [8], Rwanda [1] and many other Bantu languages. According to Maddieson it seems more appropriate to relate prenasalized obstruents to the other obstruents of the language, rather than considering them in relation to the nasals. In many cases languages lacking simple voiced obstruent series have prenasalized obstruents at places where there is no simple nasal but where there is a voiceless obstruent. Languages as Ngizim and Paez have no plain voiced stops but have voiceless stops at places matching their prenasalized obstruents. Maddieson adds that prenasalized are subject to the generalization that a prenasalized obstruent does not occur unless an obstruent on the same (or similar) place of articulation occurs in the same language. This is conform to 96.1% of the cases in UPSID [7].

Another interesting case along the lines presented by Solé is the case of languages where there are pre- and post oralized nasal consonants (e.g. [bmb]). These languages are described as having pre-oralized nasals consonants [bm], post-oralized consonants [mb] as allophones of plain nasals (e.g. /m/). An interesting fact in relation with Solé's discussion on post-nasal voicing is the observation of variations in the realization of the series of allophones of plain nasals (e.g. /m/) in Karitiana. Indeed Storto [9] and Storto and Demolin [10] report variations in the pronunciation of pre-and post-oralized allophones ([bmb]) in which the pattern found in variation is one in which pre- and post-oralized nasals vary with simpler forms, all of them keeping some level of oralization. The most commonly found variant is one in which the vowel preceding the nasal is nasalized and therefore the pre-oralization is lost. This suggests that the stronger environment is the post-oralized (that would in other languages be called prenasalized) which is the case where there is post-nasal voicing.

Solé also suggests that there are languages where stops are phonetically prenasalized and that this nasal leakage favors voicing. Karitiana gives a likely example of this phenomenon. Indeed it has been shown by Storto [9] and by Storto and Demolin [10] that in this language where there are no phonemic voiced stops, nasal consonants have a voiced stop allophone word initially. Close examination of this allophone shows that this consonant is indeed fully voiced but that there is always a slight nasalization that precedes the oral part of the stop. This initial nasal part of the consonant that can be described as a prenasalized stop can therefore be described as an articulatory maneuver to facilitate voicing in the initial stop.

5. DISCUSSION

Three points from Beddor, Shosted and Solé's papers have been evaluated from the point of view of additional data coming from other languages. Beddor's hypothesis of a constant size of velum gesture finds support in Rwanda as well as the hypothesis that some aspects of variable vowel nasalization are due to variation in the temporal alignment of nasal and oral gestures for nasals. However more data should be examined to substantiate this point. Shosted's hypothesis that a possible source of nasalization in fricatives is their proximity to nasal consonants also finds support from Rwanda data. Solé's discussion about the phonetic content of features shows that phonological descriptions that aim at classifying segments and accounting for patterns is related to specifications of the phonetic phenomena in a complex way.

6. REFERENCES

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