First Results of an RT-MRI study on the influence of context in the synchronization of European Portuguese nasal vowels

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Introduction

and Vowel nasality evolved historically from a sequence of a vowel followed by a nasal consonant mostly in coda as in /kɐ̃pu/ *campo* 'field'. In this context European Portuguese distinguish five nasal vowels /ĩ, ũ, ẽ, õ, ɐ̃/ including two high and two mid high vowels. Oral vowels following a nasal consonant are assumed to be phonetic nasalized and not phonemic nasal (Mateus & d'Andrade, 2000). Acoustically, nasal vowels were described as including an oral portion, a nasal vowel part and a short nasal tail which could be related to a late synchronization of oral and nasal gestures in this variety (Oliveira, 2009, Martins, 2014). A late synchronization hast been also partially confirmed for Brazilian Portuguese (Meireles, 2016) and argument for rejecting the phonemic nasality (e.g., Desmeules-Trudel, 2015). The main aims of this paper are to contribute for a better description of the nasal system of European Portuguese (EP), comparing oral, nasal and nasalized vowels and the influence of proceeding consonant (oral or nasal bilabial) on the synchronisation of the velum gesture with the lips.

Method

Real-time magnetic resonance imaging (RT-MRI) has been recorded from 16 speakers of European Portuguese. So far, we will be presenting data from 3-5 speakers. The corpus consisted of minimal pairs containing all oral and nasal vowels in two syllables words. Additional materials were recorded for further modelling of variability in the production of nasality in a total of 91 lexical words. All words were randomised and repeated in two prosodic conditions within a carrier sentence. Each speaker read four different randomisations of the list.

RT-MRI Acquisition: Recordings were conducted at the Max-Planck-Institute in Göttingen, Germany, using a 3T Siemens Prisma Fit MRI System equipped with a 64-channel head coil. MRI acquisitions involved a low-flip angle gradient-echo sequence with radial encodings and a high degree of data under sampling. The procedure allowed for real-time movies in a midsagittal plane of the speaker at 50 fps. Speech sound was synchronously recorded using an optical microphone (Dual Channel-FOMRI, Optoacoustics) and annotated using Praat.

RT-MRI Processing: The RT-MRI data for the considered speakers was systematically processed using semi-automatic methods aligned with Silva and Teixeira (2015, Cunha et al, 2019) resulting in sequences of vocal tract contours. Based on the annotations of the audio, the contours of interest for the target sounds and contexts were identified and the data for notable articulators (lip aperture and velum height) obtained, over time. The data for the multiple repetitions of each vowel were normalized to the duration of the longest vowel to enable their alignment and the computation of an average curve for analysis.

Results

As a notable example of what we will present, considering the described corpus and methods, Figure 1 shows the evolution of lip aperture and velum height and during the vowel interval (segmented acoustically, marked in the turquoise vertical lines) for speaker 8458. The yellow line corresponds to ....

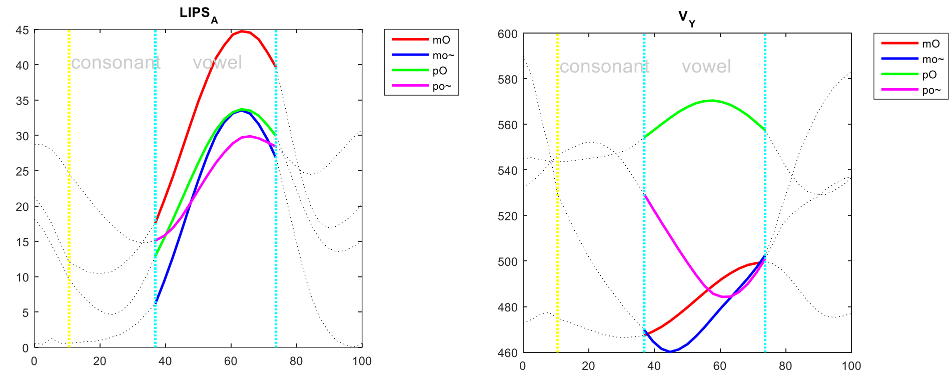

Figure 1 – Lip aperture from the beginning of the gesture for the bilabial till closure after the vowel and the corresponding evolution of velum height evolution for this interval along the production of vowel /O/ and its nasal congener /o~/ for preceding consonants /m/ and /p/ as in /mOte/, /mõte/, /pOte/, and /põte/.

The left panel shows the articulatory movement of lip aperture defined as Euclidean distance between both lips. These figs exemplified what our preliminary results show: the lowest velum position precedes the target oral vowel in /mO/ and can be situated in the first third of the vowel for the nasal congener /mõ/. The lowest position of the velum is more delayed for the phonemic nasal vowel after the oral consonant in /põ/. The velum remained raised in the production of oral /pO/. At the end of the acoustic vowel, the tendency for a raise of the velum (except /pO/ naturally) is observed, to prepare for the coming oral consonant (/t/).

Conclusions

The velum lowering associated with nasal vowel is indeed late in the acoustic vowel after oral consonants, when compared with nasal surrounding consonants. The implications of these timing for acoustics and the definition of vowel nasality may be worked out in order to better understand the relationship between velum, acoustics and perception.

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