Gestural coordination of nasal *diphthongs in Brazilian Portuguese*

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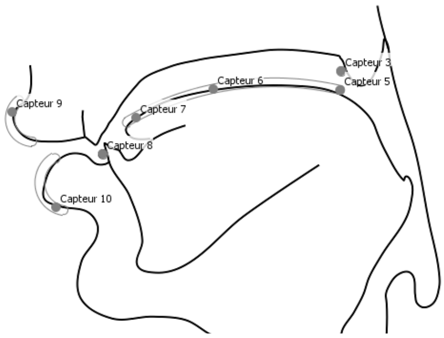
The aim of this study is to analyze the back nasal diphthong /ãw̃/ in Brazilian Portuguese (BP). Nasal diphthongs (ND) are rare in the world's languages. In the BP spoken in São Paulo, there is a phenomenon called nasal diphthongization. Our aim is to define this segment from an articulatory point of view and to show how speakers control this articulation. The results presented in the paper are part of an ongoing research. Phonological descriptions of BP describe ND as the equivalent of oral vowels with a [+nasal] feature. Mattoso Câmara Jr. (1962) proposes the following syllabic representation: /VGN/ (vowel, glide, nasal). In this case nasalization is only characterized by an oral/nasal coupling. However the velum opening and its temporal displacement should be taken into consideration. The dynamics of a ND gesture is more complex than binary categories. According to Cagliari (1977) nasal diphthongization may occur in different degrees with all nasal vowels from PB. How do we define a ND? Is the nasopharyngeal coupling the single gesture responsible for nasalization? Is the gestural coordination between tongue displacement and the velopharyngeal aperture relevant? Acoustic and aerodynamic data were collected with an EVA2 workstation and with an Electro-Magnetic Articulograph 2D. Data were recorded in small sentences [dʒigʊ __todʊ dʒiɐ] including a set of words containing nasal and oral diphthongs repeated 5 times. 10 minimal pairs were listed: [paw] x [pãw̃]; [saw] x [sãw̃]; [maw] x [mãw̃]; [taw] x [tãw̃] and [kaw] x [kãw̃]; 6 speakers were recorded. A silicone mask was fixed on the mouth of speakers to record oral airflow and nasal olives fixed on a small tube connected to the transducers allowed the recording of nasal airflow. 1 female speaker participated in the EMA 2D recordings. Pellets were glued on the following regions: nose, upper/lower lip, upper incisor, tongue tip, tongue body, tongue dorsum and on the velum surface. According to the following illustration.

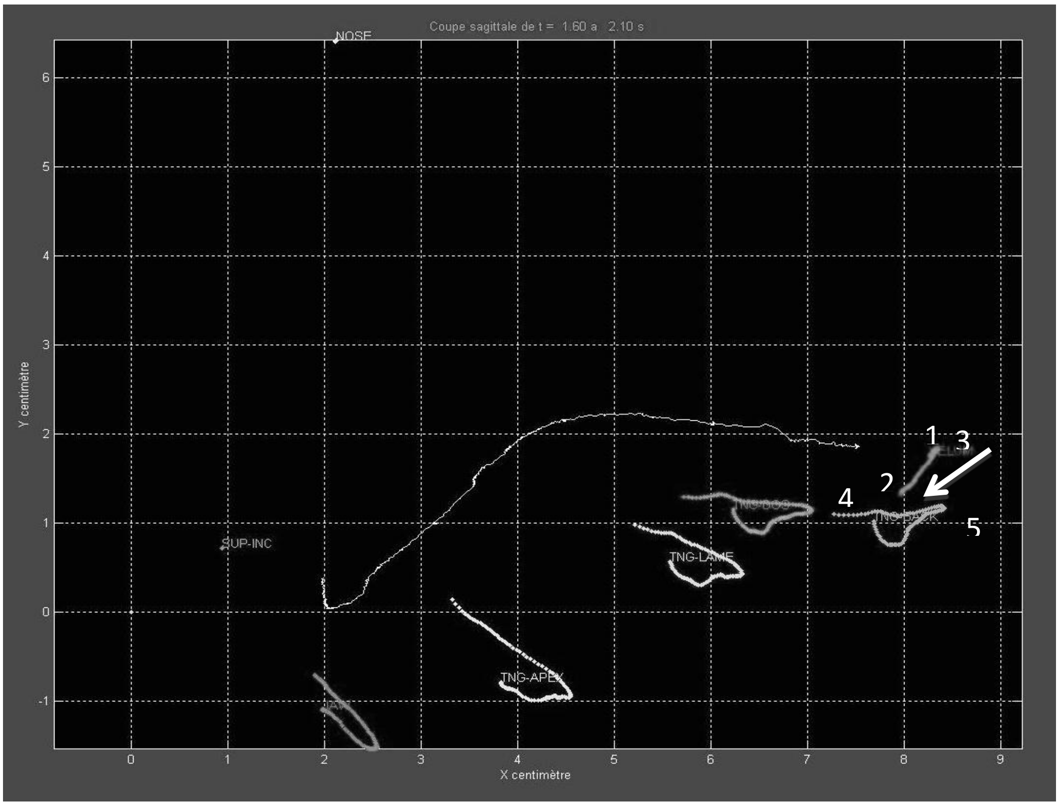
Figure 1: Pellets were glued on the following regions: *Capteur* 2: upper incisor, *Capteur* 3: velum surface, *Capteur* 4: nose, *Capteur* 5: tongue dorsum, *Capteur* 6: tongue body, *Capteur* 7: tongue tip, *Capteur* 8: lower incisor, *Capteur* 9: upper lip and *Capteur* 10: lower lip.



As ND acoustical duration (μ = *288ms*; 15 *sd*) is greater than the oral diphthongs (μ =*190ms*; 10 *sd*). Therefore we can hypothesize that oral and nasal diphthongs move the articulators with a different timing. Formants trajectories in oral diphthongs move more gradually from [a] to [w]. Indeed F1 and F2 are more flat and compact and F2 has a light downward movement to 1000Hz in [w] region. F3 has a rising movement from 2500Hz in [a] to 3000Hz in [w]. In the nasal diphthong F2 has a progressive decrease from 1800Hz, in [ã], to 1000Hz in [w̃] and the resonances are weaker. F3 has an ascending trajectory to high frequencies towards in [w̃]. The formants movements are more prominent for a ND. The figure 2 shows the velum displacement on *y*-*x*-axis.

Figure 2: Electromagnetic pellets displacement. Cross section of a window image of the words [sãw̃] during t = 1.60 a 2.10 s. The subject is a female speaker. The upper line is the palate. 1 = velum onset time. 2 = velum target. 3 = velum offset. 4 =

tongue back onset time. 5 tongue back target. Dynamic pellets displacement on *y-x*-axis. Data produced with Trap software analyzer of the 2D space geometric parameters on *x-y* coordinates in centimeters.



The white arrow shows the gestural configuration between the velum captor and the thong back captor. The results presented herein were estimated through the data collected where there is a constriction of the tongue dorsum with the velar region. In this case a nasal velar appendix emerges because these movements take place simultaneously. On the *x*-axis, the tongue dorsum onset displacement starts in 4 and reaches the target in 5. On the *y*-axis the velum onset displacement starts in 1 and reaches the target in 2. In oral diphthongs the gestural has a different oscillation (tongue dorsum and velum aperture). It implies that the angular opening of the tongue dorsum displacement and the force applied to the system are different. This might be a distinctive parameter between nasal and oral diphthongs. This analysis is corroborated by aerodynamics data. The shape of nasal airflow has 3 phases in 83% of the 300 occurrences recorded for back and front ND. This is: the velum opening (1 to 2), a stable portion of nasal airflow (2) and a sharp peak (2 to 3). This final nasal peak is another evidence for the nasal velar appendix emergence. The variation of nasal airflow suggests that the tongue and velum displacements give a more complex configuration of the tract geometry in ND. In ND, the system seems ‘damped’, the tongue displacement is slower and there is an overshoot of the tongue movement closing the oral cavity.

References

Cagliari, L. C. 1977. *An experimental study of nasality with particular reference to Brazilian portuguese*. PhD Dissertation. University of Edinburgh. / Mattoso Câmara Jr., J. 1969. Problemas de Lingüística Descritiva. Petrópolis: Vozes.

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