The aerodynamics of vowel nasality and nasalization in Brazilian Portuguese

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There is an ongoing debate on the phonological status of vowel nasality in Brazilian Portuguese (BP).
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- Some authors argue in favour of a representation that contains two elements (an oral vowel followed by a nasal consonant; Mattoso Câmara Jr. 1970; Wetzels 1997)
- Others argue that nasality is specified in the “underlying” representation (Raposo de Medeiros, 2011; Sampson, 1999)
• Tautosyllabic nasal vowels (TNVs) are often extensively nasalized
  • canto [kẽtũ] ‘I sing’
Introduction

• Tautosyllabic nasal vowels (TNVs) are often extensively nasalized
  • canto \([kêtv]\) ‘I sing’
• There exist (heterosyllabic) coarticulated nasalized vowels (HNVs)
  • cama \([kâmə]\) ‘bed’
Introduction

• Arguments in favour of two-unit representation

No firm language-internal evidence in favour of a contrast between oral and nasal vowels

TNVs are unpacked in loanwords and in some morpho-phonological processes

TNVs have a longer duration than (stressed) oral vowels
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Studying nasal and nasalized vowels in BP is also complicated by:

- Variability in production
- Mid-vowels [˜ e, ˜ o] are diphthongized [˜ e ʃ, ˜ o ɻ] in Southeastern dialects (São Paulo)
- Emergence of a nasal coda
- k˜ ʃtU 'I sing'
- General difficulties for acoustic analyses of vowel nasality
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- Nasal vowels that are the result of a phonological rule of nasalization display plateau-like nasal airflow throughout the duration of the vowel

- Nasalized vowels that are the result of a phonetic (coarticulatory) rule of nasalization display cline-like nasal airflow towards the end of the duration of the vowel
Research question

The following experiment investigates:

• What are the nasal airflow patterns of BP TNVs, HNVs and oral vowels?
• Do they correspond to plateau and/or cline patterns?
• To what are the potential differences due?
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• English as a second language for all participants (various self-reported levels of spoken proficiency)
• Spanish and French for some participants - observing the data of those participants did not suggest interference from French on their productions of nasal(ized) vowels
Methods

Procedure
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• 90 randomized sentences pronounced twice per participant, containing stressed TNVs [ɨ, ɨ̃, öğret], HNVs [ã, ẽ, {o̞}], as well as oral [a, e, o]

• [ɨ̃, ũ̃] were not included as [ũ̃]’s tongue position restrains velum opening
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Procedure

- 90 randomized sentences pronounced twice per participant, containing stressed TNVs [ã, õ, õ], HNVs [ã, õ, õ], as well as oral [a, e, o]
  - [ĩ, ũ] were not included as [ũ]’s tongue position restrains velum opening
- Airflow measurements made with the EVA2 system setup
Methods

Segmentation and data preparation

- Hand segmentation based on the vowels' acoustics (nasal coda not included in the duration of TNVs)
- 1882 target vowels for analysis
- One Praat script for extracting duration values, one Praat script for extracting airflow data (every 5% of duration; 31 points between 0% and 150% of duration)
- Data was imported into R, appended with new information
- Negative values were replaced by 0
- Calculation of nasal airflow ratio:
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  \frac{\text{Nasal airflow value}}{\text{Oral airflow value}}
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\[
\text{Nasal airflow value} = \frac{\text{Nasal airflow value}}{\text{Nasal airflow value} + \text{Oral airflow value}}
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## Results

### Duration values

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- Recall that the nasal coda was not included in the durations of TNVs.
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General nasal airflow results

![Diagram showing nasal airflow ratio and values over normalized time.]

- Same curve patterns between raw nasal airflow and nasal airflow ratio.
- Nasal airflow ratio starts increasing earlier for TNVs than HNVs (diverge at 50% of duration).
- Nasal airflow stays low for oral vowels.

1 Note: Nasal airflow ratio of oral vowels increases after vowel offset, probably due to oral airflow decrease.
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Patterns of nasal airflow

• A lot of observed variability across speakers
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  - FBP2: 5 participants display this pattern
  - FBP5: 3 participants
  - FBP7: 3 participants
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- Pattern 3: Plateau-like pattern for HNVs and TNVs, starts increasing earlier for TNVs
Discussion and conclusion

Duration

- Oral vowel are slightly longer than TNVs → against the "two-time-units" explanation
- There does not seem to be a major difference, TNVs can be considered single phonemes with regards to their duration
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• General clinal-like pattern for TNVs and HNVs → according to Cohn (1990), result of a phonetic rule of nasalization
• Support for the hypothesis that TNVs are formed by two elements
• There is a lot of individual variability → the opposition between HNVs and TNVs is not phonetically robust
• This does not exclude the possibility that TNVs are contrastive in BP

What could account for the observed variability?
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• TNVs are “on their way” to become phonological in BP
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Most authors recognize the existence of extensive nasalization 2
Individual variability is important 3
Phonologization theories predict the occurrence of an intermediate stage during which speaker variability can be important

We hypothesize that the differences between HNVs and TNVs are due to the “nearly contrastive” status of vowel nasality in BP.

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Nasal and nasalized vowels in BP cannot be considered other than ambiguous because

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• They are highly variable
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Other hypothesis: Phonotactic restrictions on the language that motivate production


Acknowledgements

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Questions?

Muito obrigado!