

From devoicing to apocope: an acoustic study of  
poststressed high vowel lenition in  
Brazilian Portuguese

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# *High vowel devoicing in unstressed position*

- **Vowel reduction with devoicing: a common cross-linguistic phenomenon**
  - Appearing in many languages (e.g., Tsuchida, 1997; Torreira & Ernestus, 2010).
- **Highly variable** (Gordon, 1998; Chitoran & Marsico, 2010):
  - Across linguistic contexts;
  - Intra and inter-languages;
  - Intra and inter-speakers.
- **Investigated under different theoretical perspectives:**
  - Autosegmental phonology: delinking or deletion;
  - Articulatory Phonology (Browman & Goldstein, 1989): variation in gestural overlap and magnitude (Chitoran & Iskarous, 2008).

# *Apocope and devoicing in Brazilian Portuguese*

- **Brazilian Portuguese** (henceforth **BP**): reported to have **final V deletion**, especially with /i/ and /u/, after a **voiceless C** (Rolo & Mota, 2012), i.e., “apocope”.
- **Meneses (2012)**: a **production experiment** to **bring out the gradient side** of this “apocope”
  - Acoustic analysis of **poststressed vowels** between **voiceless consonants**;
  - **Partially devoiced** and **fully devoiced** vowels: **over 50%** .

# *Aims*

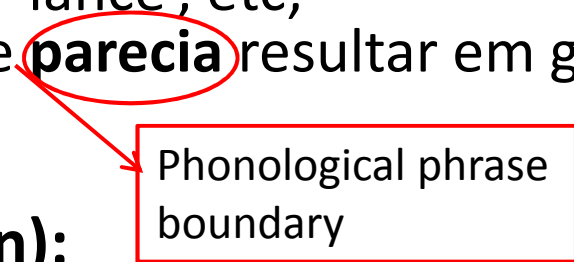
- To address the following questions:
  - Extreme vowel lenition:
    - Apocope x devoicing?
    - Are there vowel traces in the acoustic signal?
  - What about perception?
  - What kind of theoretical account?
    - Categorical?
    - Gradient?

# Hypotheses

- There is an **ongoing lenition change** that takes place in **three steps**:
  - **Vowel reduction**;
  - **Partial or total overlap** with **preceding consonant**;
  - **Perceptually-driven apocope**.
  
- All three steps **coexist** in **synchronic variation**.

# Method

- **Six female speakers**
  - Northeastern BP dialect.
- **Post-stressed syllables in ‘CVCV disyllables:**
  - **Target syllables:** /si, sa, su/;
  - **Words:** ‘caça’, ‘aço’, ‘passe’, ‘lance’, etc;
  - **Carrier sentences:** “O passe **parecia** resultar em gol”.
- **Measurements:**
  - **Experiment 1 (production):**
    - Duration;
    - First spectral moment;
    - Formant Centralization Ratio (FCR) x Vowel Space Area (VSA).
  - **Experiment 2 (perception):**
    - 5 point forced choice procedure;
    - Reaction time.
- **Praat & Statistica used for data analysis.**

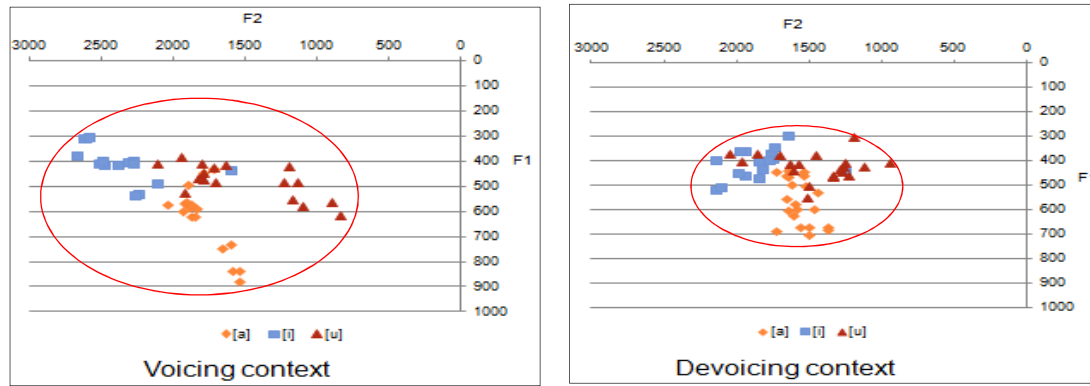


Phonological phrase boundary

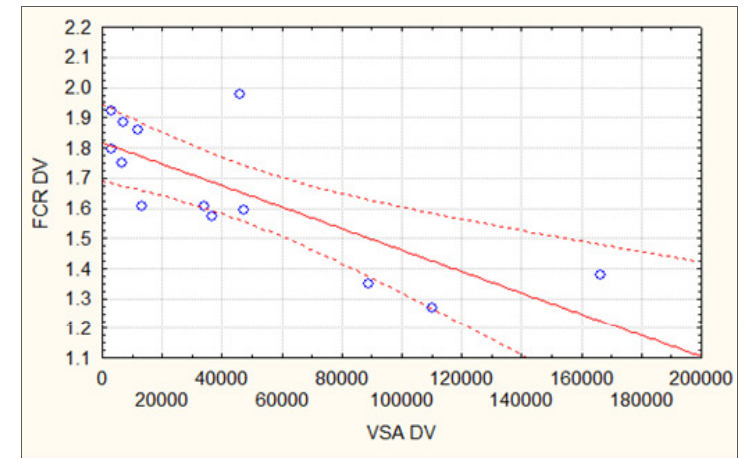
# Experiment 1

- **Segmentation and annotation of target words and syllables with Praat;**
- **Manual labeling of unstressed syllables.**
- **Automatic extraction:**
  - Vowel formants;
  - First spectral moment;
    - Fricative noise above 4 kHz in syllables “without” vowel.
  - Duration of unstressed units:
    - Syllable;
    - Fricative noise.
- **Computation:**
  - **FCR** =  $(F2u+F2a +F1i+F1u)/(F2i+F1a)$ ;
  - **VSA** =  $ABS ((F1i*(F2a -F2u)+F1a *(F2u-F2i)+F1u*(F2i-F2a ))/2)$ .
- **Statistics:**
  - ANOVA;
  - Pearson correlation.

# Vowel space area and correlation between FCR and VSA



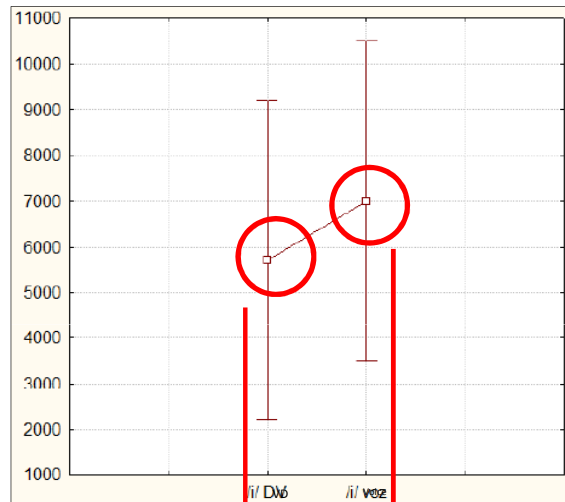
Note the clear **vowel space reduction**:  
voiced vowels **more centralized** in  
**devoicing contexts** (right panel).



High **negative** correlation ( $r(11) = -0.77$ ,  $p = 0.002$ ) between FCR and VSA: **incompletely devoiced vowels lose gestural magnitude** in devoicing contexts.



# Centroid of fricative noise above 4 kHz in syllables with and “without” vowel

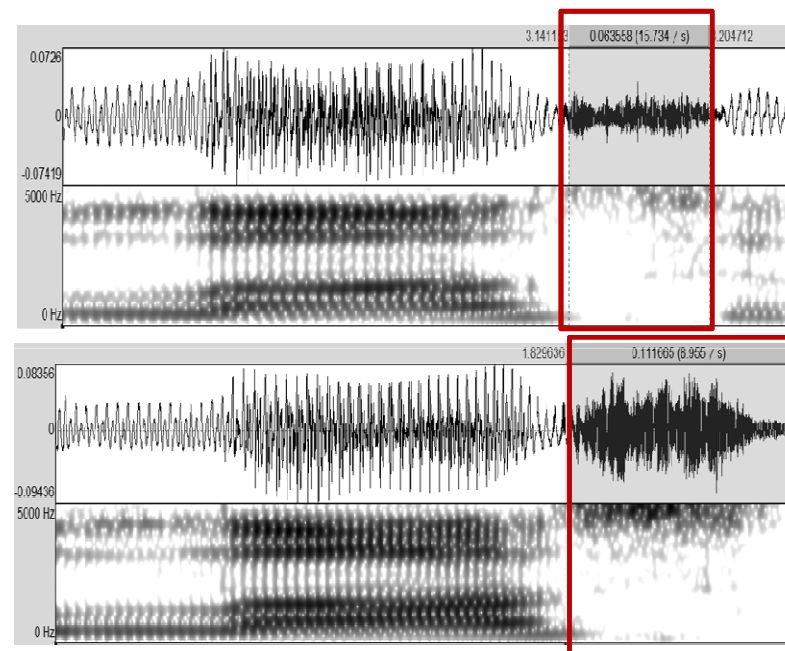
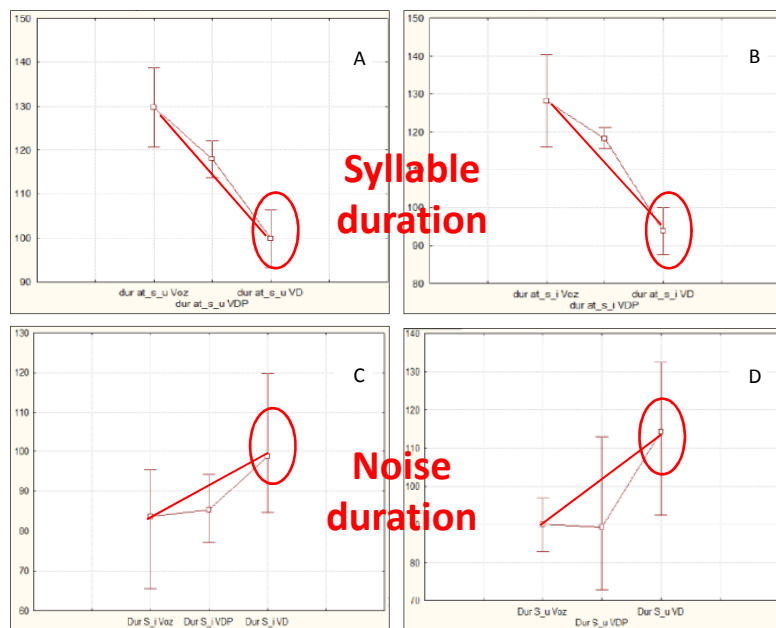


Noise with  
devoiced  
Vowel

Noise with  
voiced  
Vowel

When the **vowel** is apparently absent, a **lower average centroid** indicates its presence within the [s] noise (e.g., for [i],  $t(2) = -6.64$ ,  $p < 0.02$ ).

*Syllable duration (A-B) and duration of [s] noise (C-D) with voiced V, partially devoiced V, and totally devoiced V.*

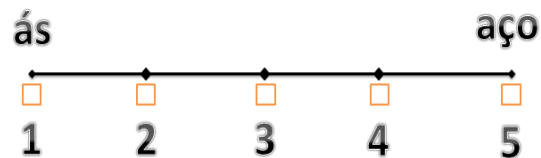


Mean **length** of [s] noise: significantly **greater** with **V devoicing** than with **voicing, total or partial** (Tukey post hoc test).

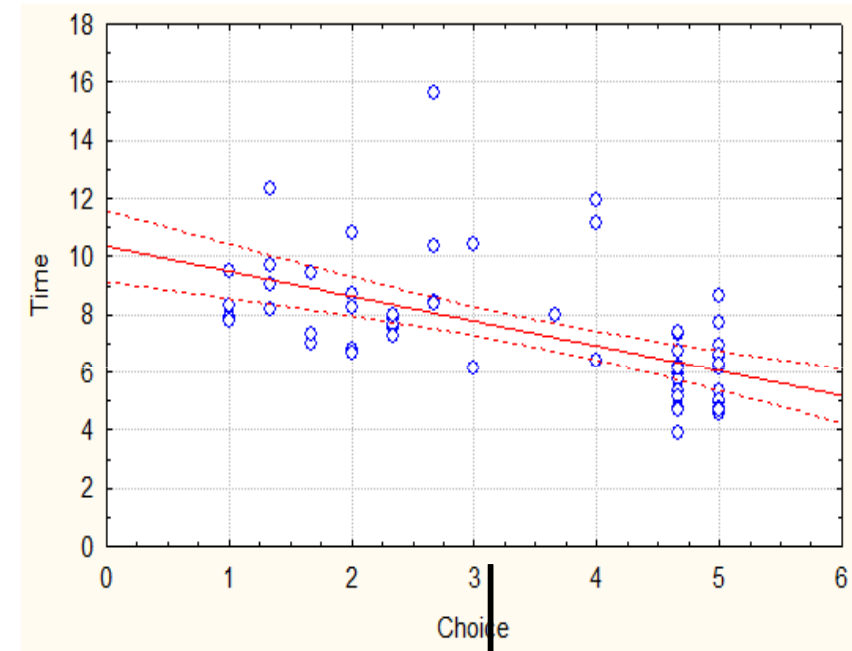
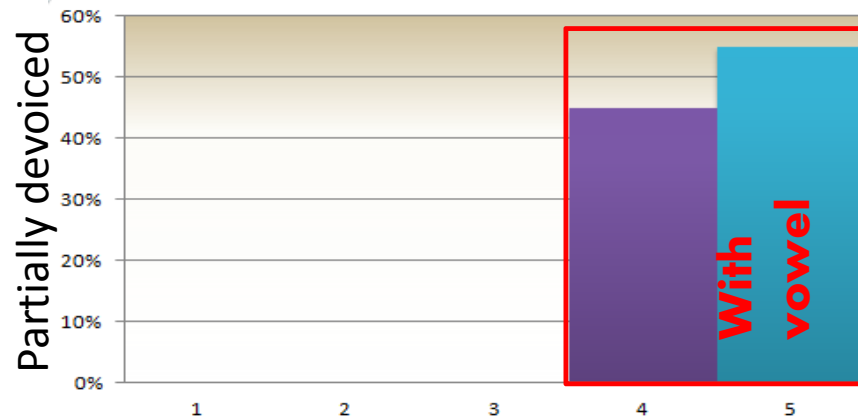
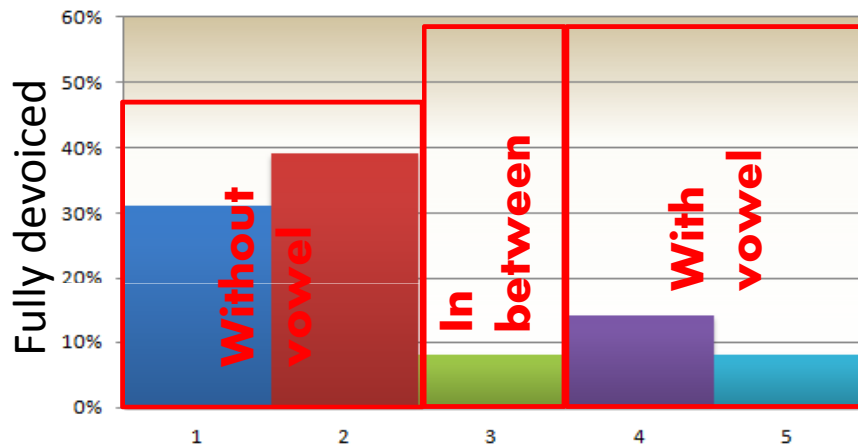
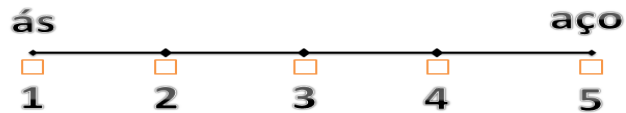
“Compensatory” **lengthening** of [s] where **vowel** is **fully devoiced**.

# Experiment 2

- **Subjects:** 4 of the subjects from Experiment 1;
- **Materials**
  - **Recordings:**
    - *ás* ['as]/*aço* ['a.su], *paz* ['pas]/*passe* ['pa.sl], *lãs* [lãs]/*lance* [lã.sl].
  - **Stimuli:** words with devoiced/partially devoiced vowels.
- **Procedure:**
  - Subjects instructed to listen and choose from a five point scale:
    - 1 – without vowel
    - 5 – with vowel
  - **Measurement:**
    - Mean percentage of each rating.
  - **Statistics:**
    - Spearman correlation: mean percentage x mean reaction time.



# Auditory Identification



Longer times for words with devoiced vowel  
 (Sperman's  $r(58) = -0.64, p < 0.0001$ ).

# Summary

- Production
  - **Lower average centroid:** presence of **vowel** when it is apparently absent;
  - **[s] lengthened** where **vowel** is **fully devoiced**.
- Perception
  - Ratings of **fully devoiced** vowels **variable**;
  - Definite **bias** for **vowelless words** (70% of cases);
  - **Partial voicing** sufficient for vowel **recovery** (100% of cases).

# Conclusions

- Poststressed vowels: **no categorical apocope**, but, rather, **gradient lenition**, with increased gestural **overlap**, and **devoicing**.
- What about “compensatory” lengthening of [s]?
  - **Poststressed position in weak prosodic boundaries: extreme vowel reduction;**
  - **Reduction: enhanced in devoicing contexts;**
  - **Overlap : increased in devoicing contexts.**
  - **But why does [s] lengthen?**
- A possible theoretical interpretation:
  - **Syllable oscillator:** tendency to **preserve beat strength** (Byrd & Saltzman, 1998; Saltzman et al., 2010);
  - Consonantal **closure:** increased **magnitude** and **duration**.

## *Conclusions*

- **Partial voicing** sufficient for **vowel recovery**;
- **Full devoicing** leading to **misidentification**;
- **Completely overlapped** and thus **devoiced vowels**: likely **trigger of listener-based change** of vowel apocope (Ohala , 1981).

**THANKS FOR YOUR ATTENTION!**



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