Devoicing of phonologically voiced velar stops in European Portuguese— a comparative production and perception study

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INTRODUCTION

- In European Portuguese (EP) production data (Lousada, Jesus & Hall 2010, Pape & Jesus 2011) often *voiced stops* show no discernable burst
- EP has considerable percentage of devoicing (Jesus & Shadle 2003, Pape & Jesus 2011)
- Time dynamics and distribution of voicing behaviour are not known yet
- Without burst information: How does the perceptual system extract VOT cues?

Our research questions:
1. Where and how frequently does devoicing occur for phonologically voiced velar EP stops?
2. What is the *devoicing behaviour* throughout the time course of the stop closure?
3. Which *cues* are used for the perception of voicing in EP in *absence of the burst (VOT)*?

**Production**

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<th>Method:</th>
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<td>Corpus:</td>
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<td>- 6 native EP speakers, 9 repetitions, identical speech rate</td>
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<td>- Recording of EP stops /g/ (initial+medial) in frame sentence</td>
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<td>Diga CVVCV outra vez</td>
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<td>- 4 vowel contexts /i e o a/</td>
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**Labelling:**
- Preceding + following vowel durations (CVCV)
- Stop durations (CVCV)
- Voicing status of 10 equidistant landmarks throughout stop closure (landmark1 = stop onset; landmark10 = stop offset; see figure below)

**Statistic analysis:**
- (General) Linear Mixed Models with dependent variable voicing during throughout complete closure duration

**Results:**

- **Durations** (all significant):
  - preceding vowel: voiced >> voiceless
  - closure: voiceless >> > voice
  - following vowel: no difference

- **Voicing**:
  - Vowel context significant (/a/ vs. /I/)
  - Consonant position not significant
  - Strong devoicing of voiced stops throughout complete closure duration
  - Devoicing occurred early and was maintained throughout complete stop closures

**Perception**

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<td><strong>Biomechanical modeling:</strong></td>
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<td>- Physically realistic model of Perrier et al. (2003), natural transitions</td>
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<td>- EP Durations and voicing curves all obtained from the production database</td>
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| - Fully crossed factors (3x3x7 steps):
  - Duration stop: 100 – 125 – 150 ms
  - Duration vowel: 70 – 100 – 130 ms
  - Voicing: 0 – ... – 100 [%]

**Participants and procedure:**
- 32 native EP listeners with headphones
- Procedure (analysis: GLMM):
  - Identification task: perceive /g/ or /k/?
  - Forced choice, /a o/ contexts, 5 reps.
  - GLMM analysis with three factors

**Results:**

- GLMM: All three factors are significant for voicing decision (stop duration, closure duration, voicing maintenance), interaction between voicing and stop duration
- Voicing perception depends on the ambiguity of durational values (durations between /g/ and /k/)
- More influence of the voicing cue for all ambiguous stimuli

**CONCLUSIONS**

- Strong devoicing throughout complete stop duration for all (phonologically voiced) EP velar stops
- This contradicts results for other Romance languages like Italian and Spanish (Shih et al. 1999)
- Durational differences in accordance to the literature
- These differences could be due to the different prosodic grouping of EP versus Spanish/Italian?

- Burst and VOT are not necessary for stable voicing identification
  - A weighting of vowel duration, voicing maintenance and closure duration takes over to guarantee stable perception
  - However, stimuli are generally perceived as being more voiced than voiceless (offset)

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