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

Production

Perception

Method:

Corpus:

- 6 native EP speakers, 9 repetitions, identical speech rate
- Recording of EP stops /k g/ (initial+medial) in frame sentence "Diga CVCV outra vez"
- 4 vowel contexts /i e o a/

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 stop closure (landmark 3-7), factors consonant position and vowel context

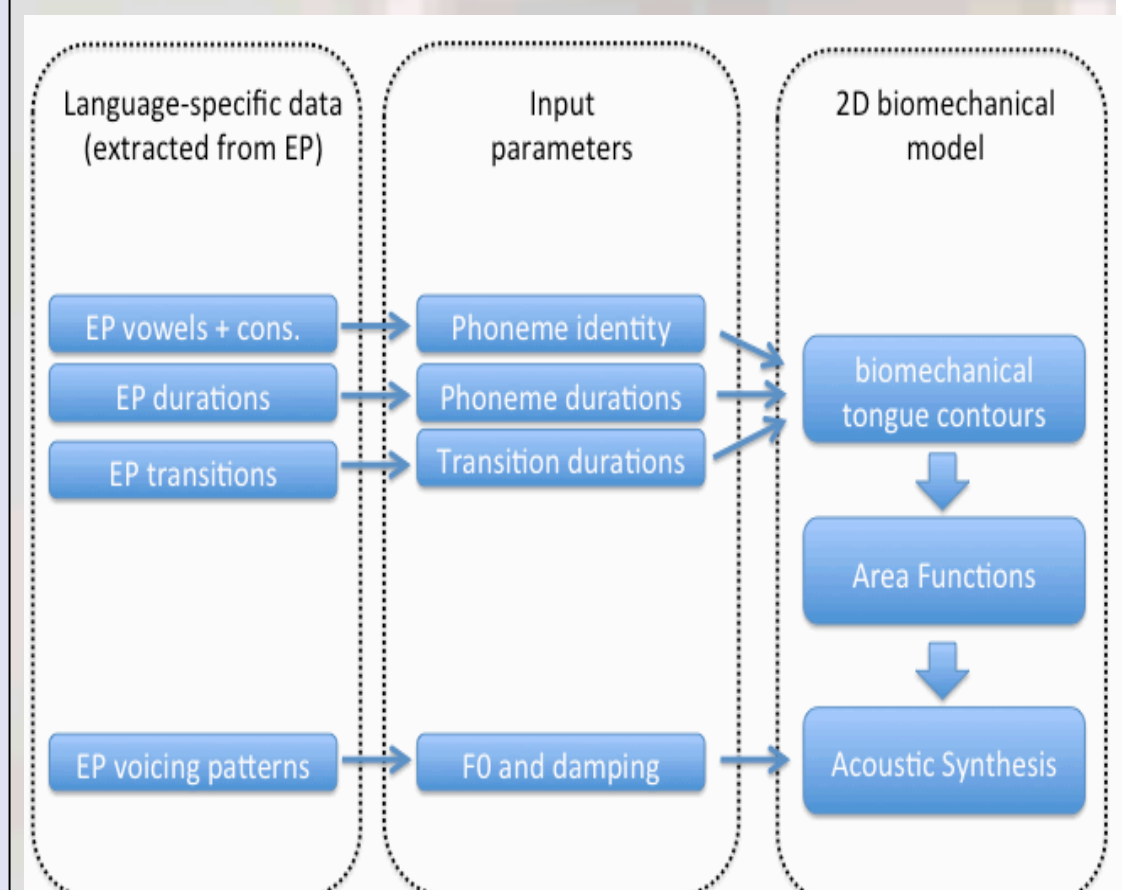
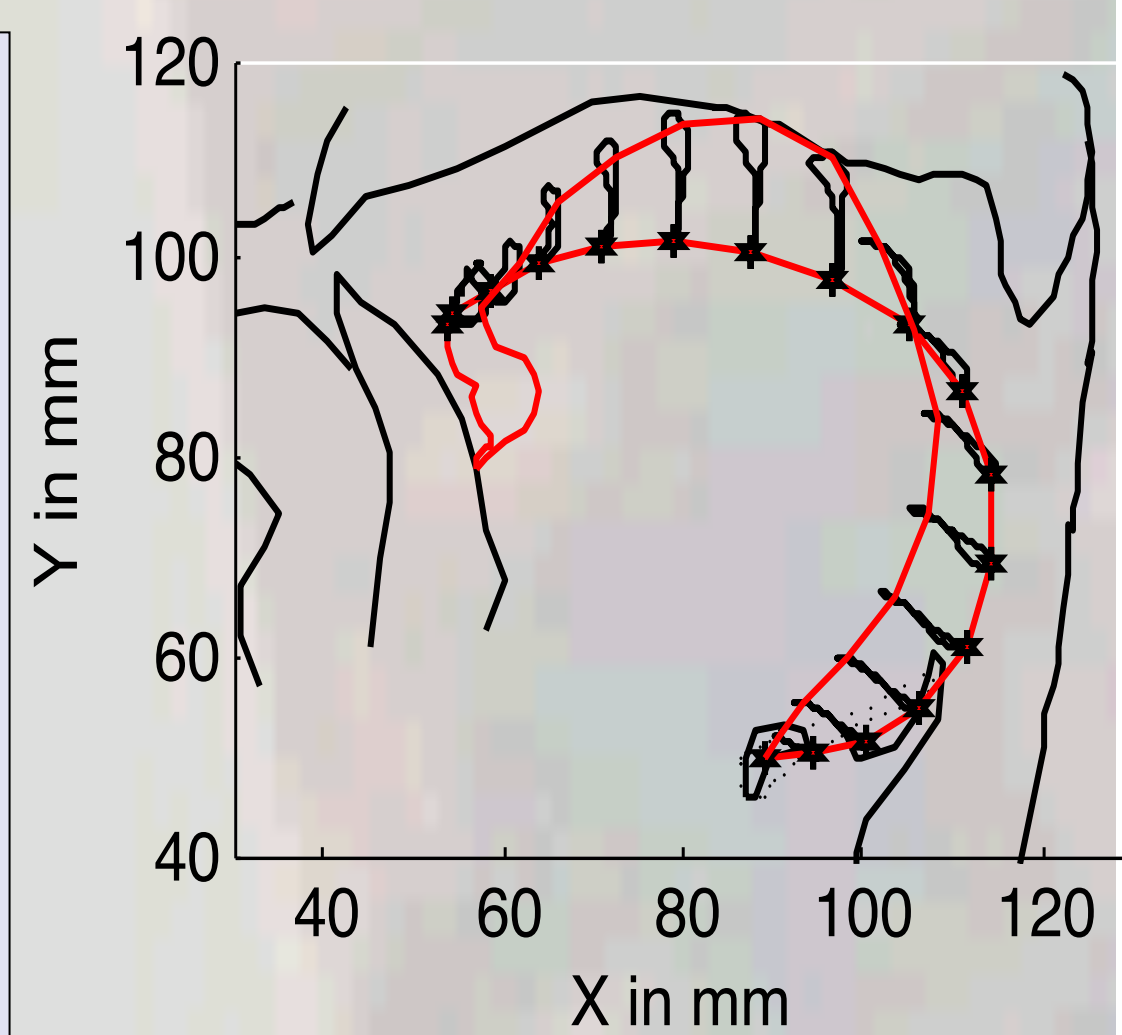
Method:

Biomechanical modeling:

- Physically realistic model of Perrier et al. (2003), natural transitions
- EP Durations and voicing curves all obtained from the production database
- 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:

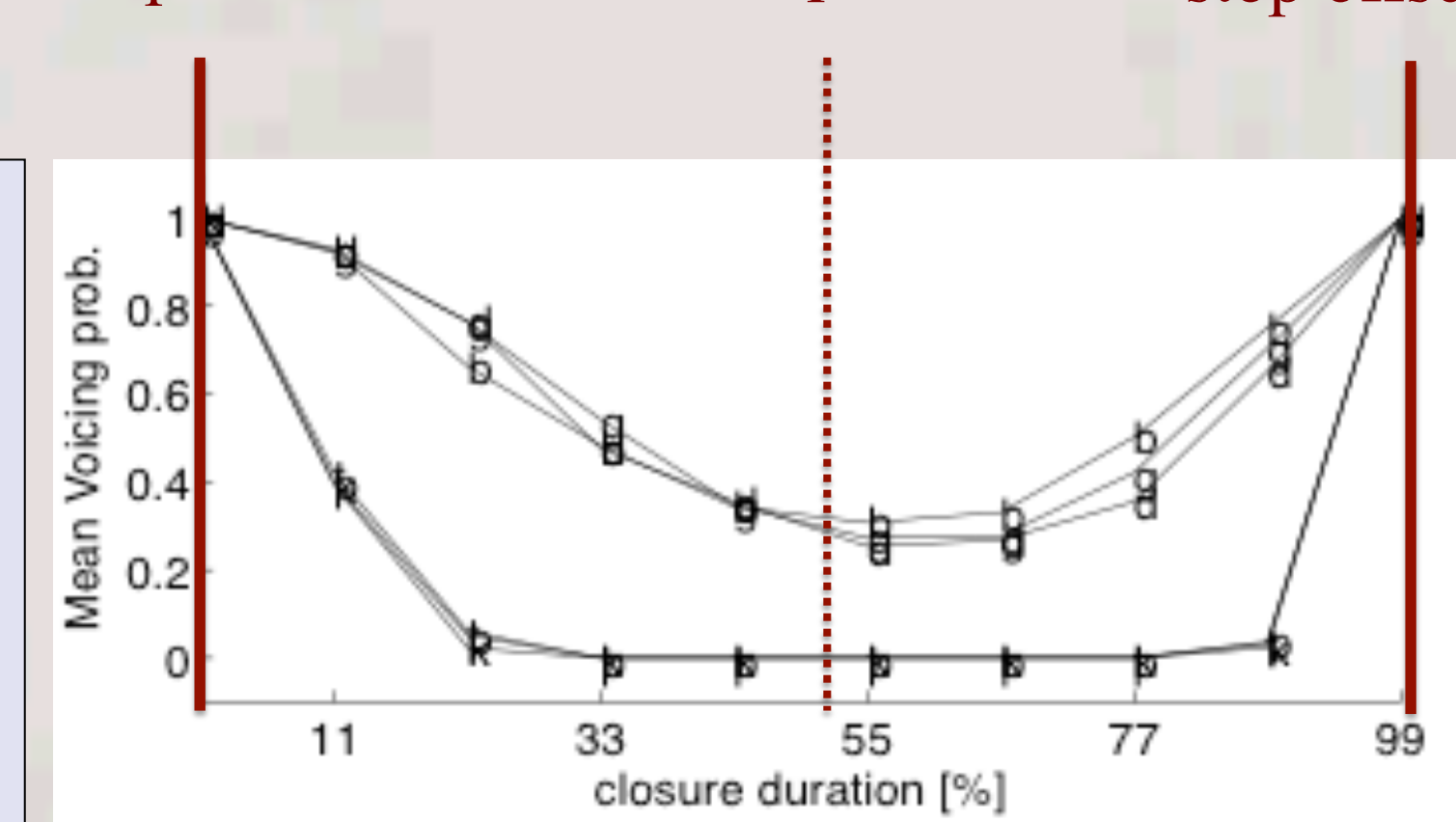
Durations (all significant):

- preceding vowel: voiced >> voiceless
- closure: voiceless >> voiced
- following vowel: no difference

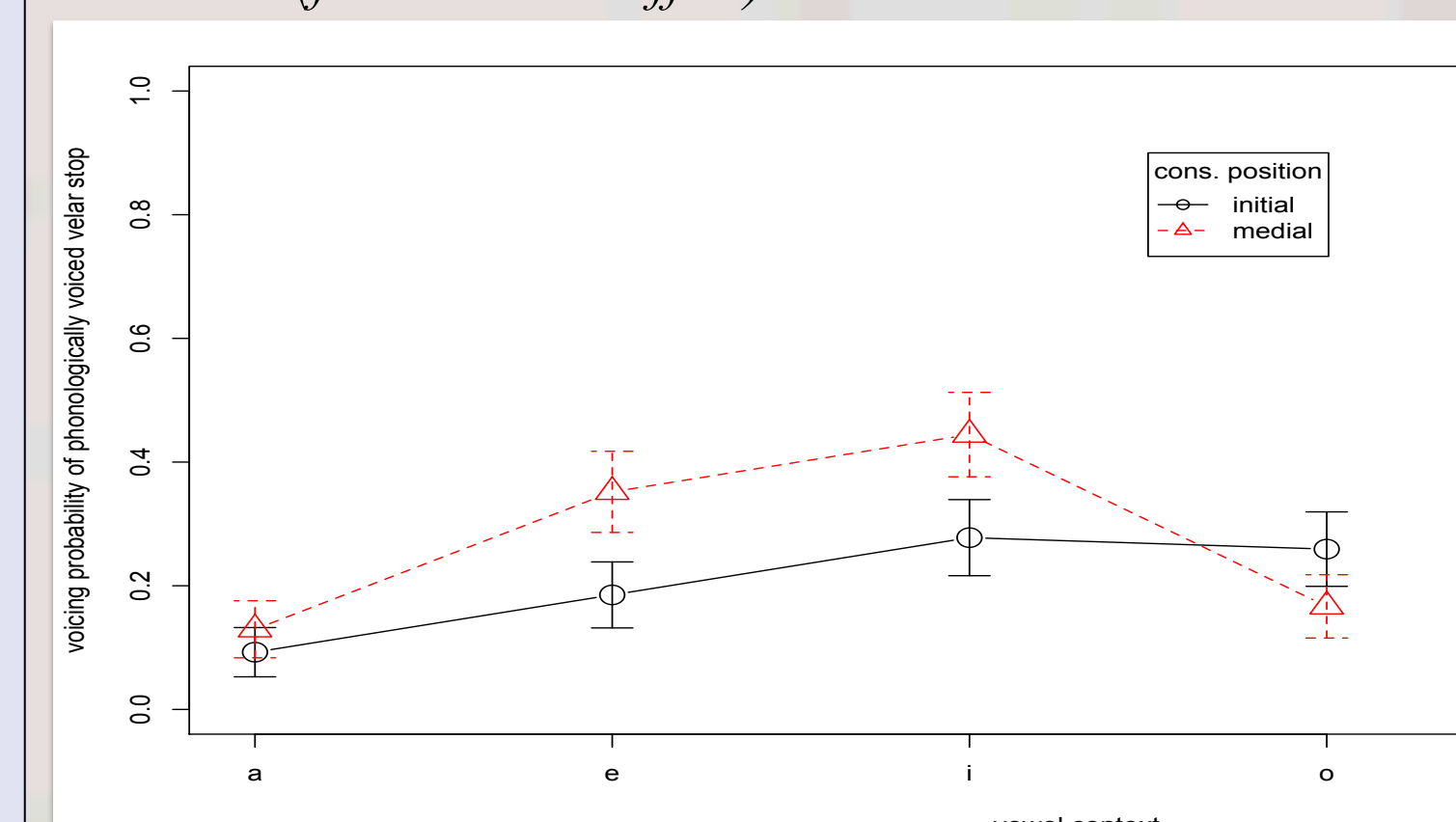
Voicing:

- 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

Landmark 1: stop onset acoustic midpoint Landmark 10: stop offset



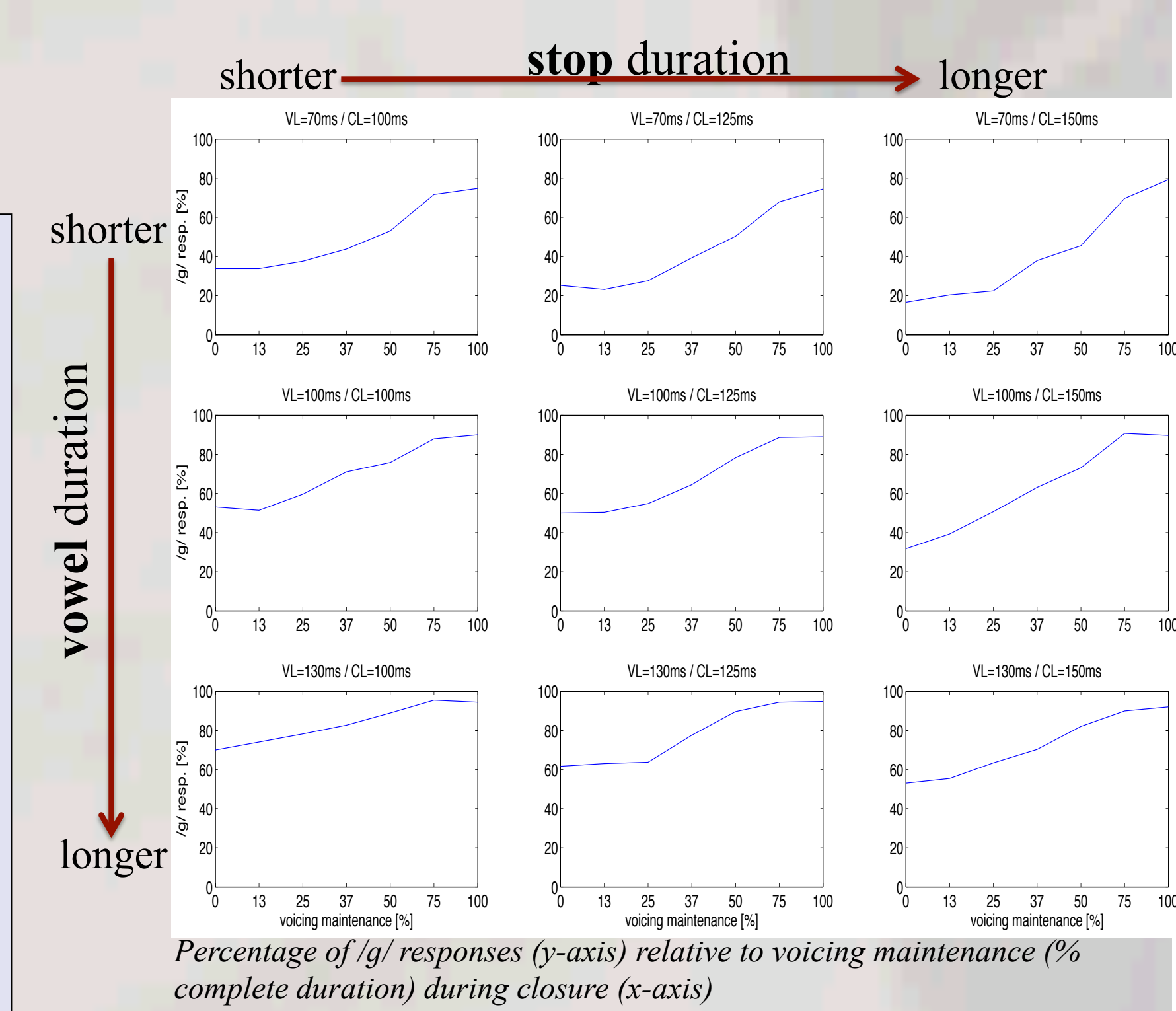
Mean voicing probability throughout the complete stop closure (from onset to offset)



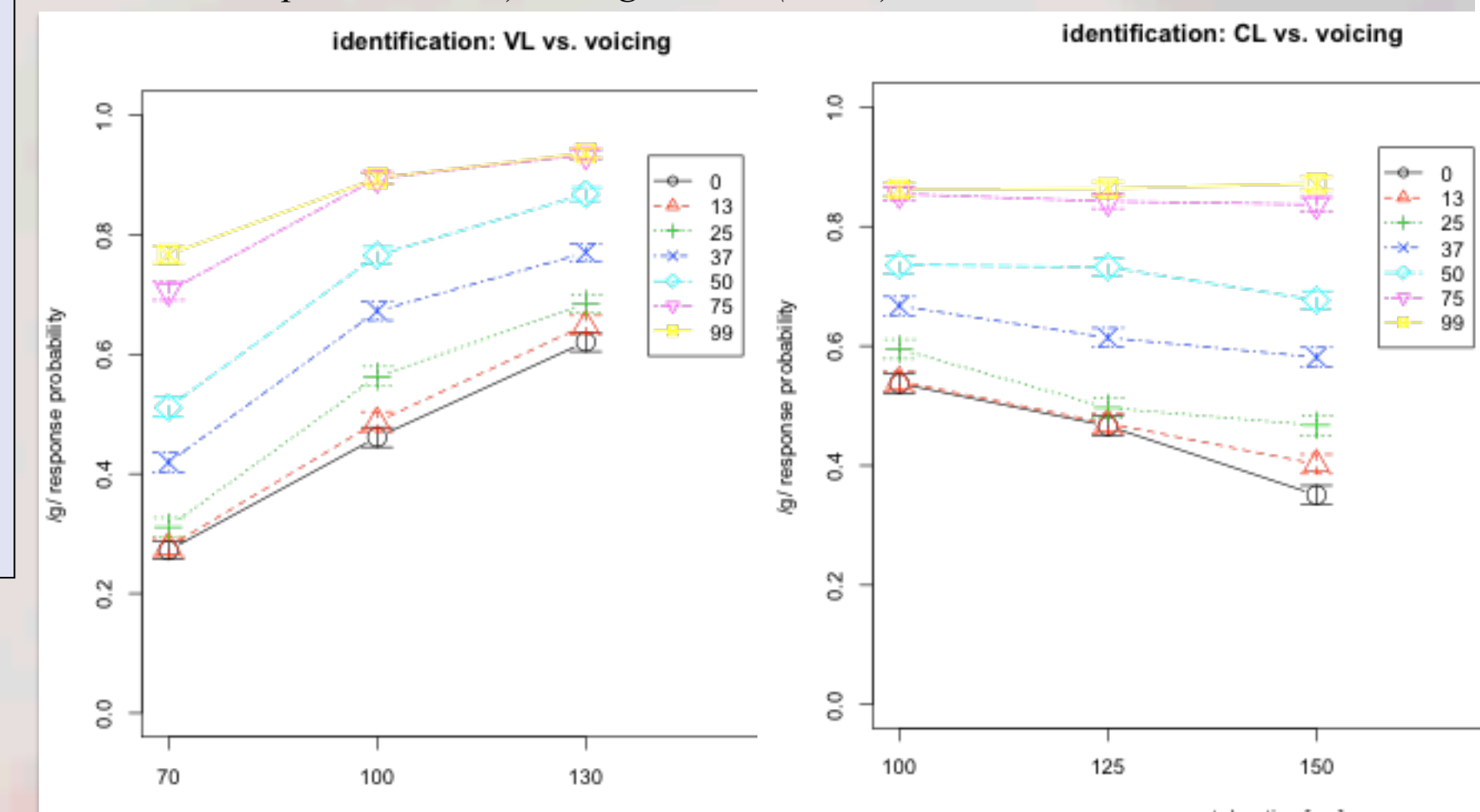
Voicing probability at the stop acoustic midpoint split by contextual vowel identity (x-axis) and consonantal position

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



Percentage of g/ responses (y-axis) relative to voicing maintenance (% complete duration) during closure (x-axis)



Interaction plots between the GLMM factors: voicing maintenance and contextual vowel duration (left) and voicing maintenance and stop duration (right)

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 thus 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)