

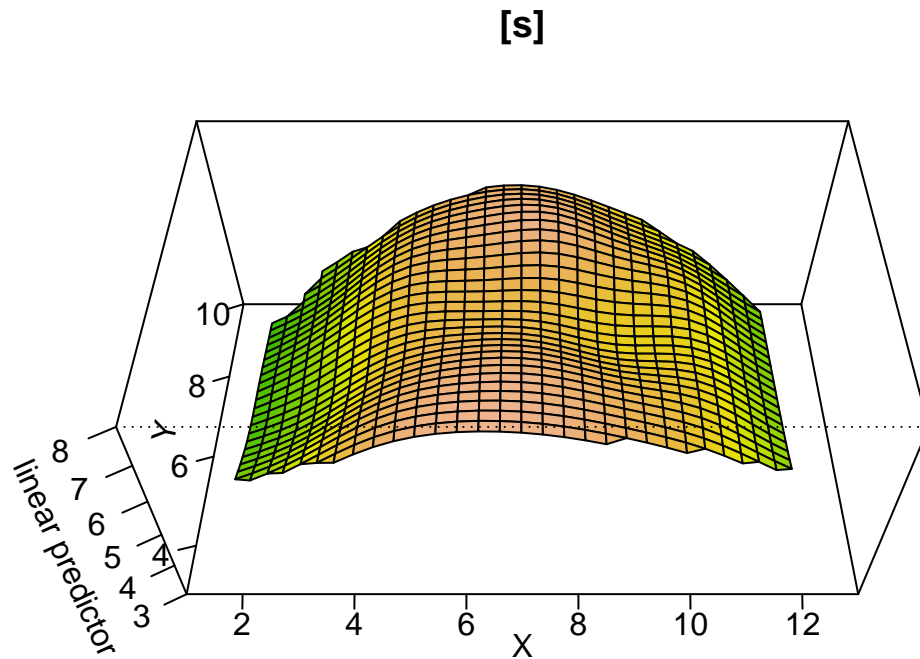
17 December 2018

Stefano Coretta

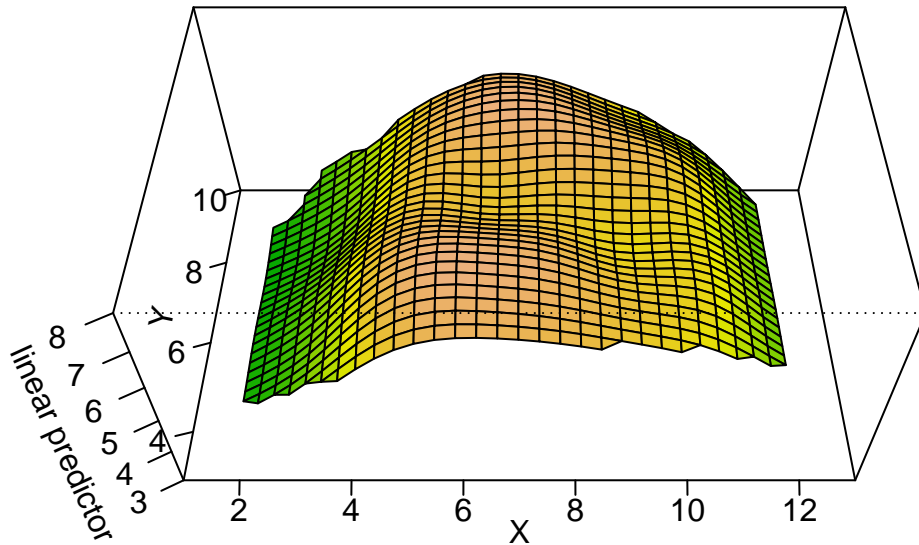
12/12/2018

1 3D tongue surface of [s] and [z]

I recorded myself in Bloomington with the 3D ultrasound machine while uttering five tokens of sustained [s] and five tokens of sustained [z]. A single 3D frame has been extracted from each token. The following plots show the output of a 3D GAM fitted to the tongue surfaces of [s] and [z].



[z]



There is a shallower groove in [z] compared to [s], and some lowering/advancing of the tongue root. Note that the tongue data have not been rotated.

1.1 Volume increase

The volume increase of [z] relative to [s] is 12.08 cm³. This estimate is based on the predicted GAM data on a surface which corresponds to the actual imaged surface. If I remember correctly, Steven Lulich estimated that a volume increase of 20 cm³ is ideal for maintenance of voicing in a voiced fricative.

2 A Bayesian analysis of the voicing effect in pre-stress vowels (/ə CV/)

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## Compiling the C++ model
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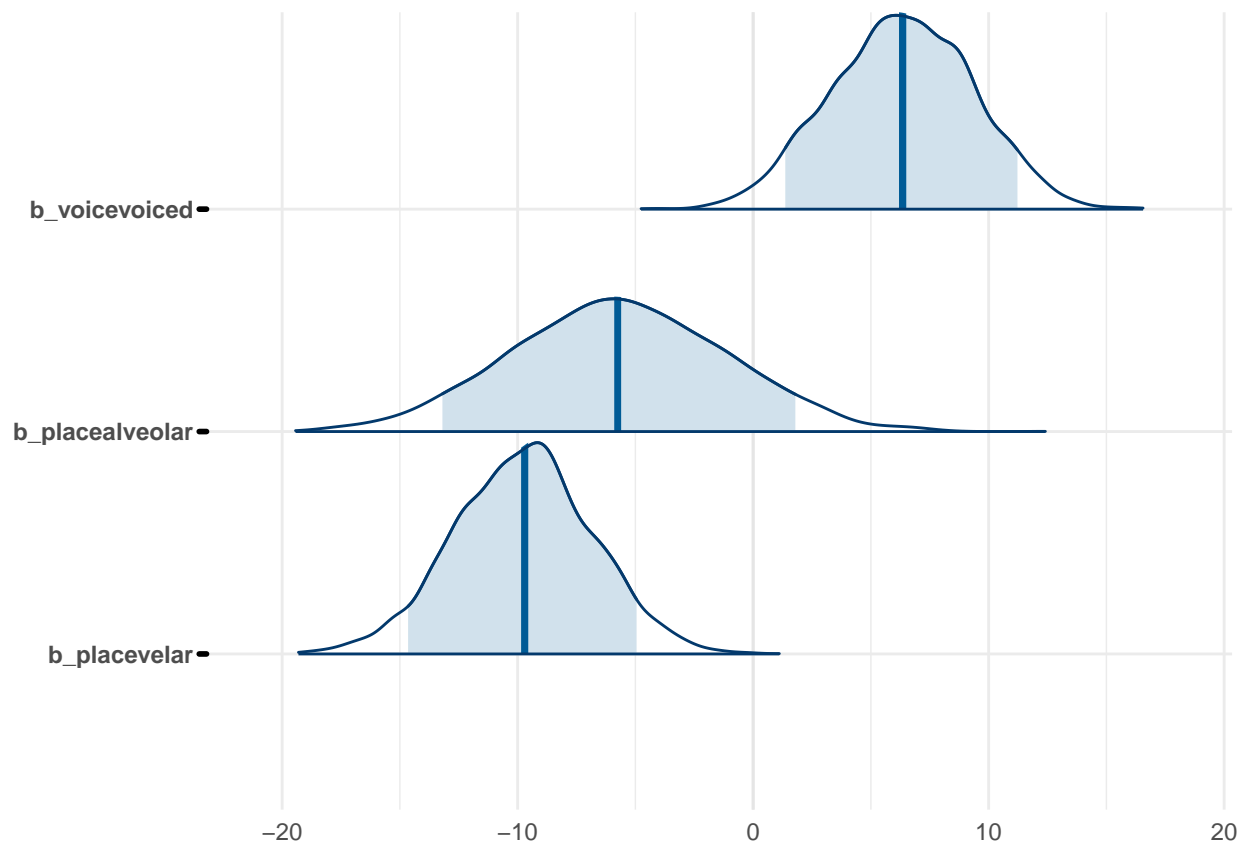
```
## Start sampling
```

Davis & Van Summers (1989) report means and standard deviations of the duration of reduced unstressed vowels followed by a voiceless or a voiced stop (*atop/adopt*). We can use a Bayesian measurement error model which takes into account the standard deviation of the vowel durations (since we don't have the individual data points that make up the means). The data is based on three speakers, the consonant following the reduced vowel can be labial, alveolar, or velar. A model was fitted to vowel duration (and standard deviation) with the following predictors: C2 voicing (voiceless vs. voiced), C2 place of articulation (labial vs. alveolar vs. velar), and a by-speaker random intercept. The following weakly

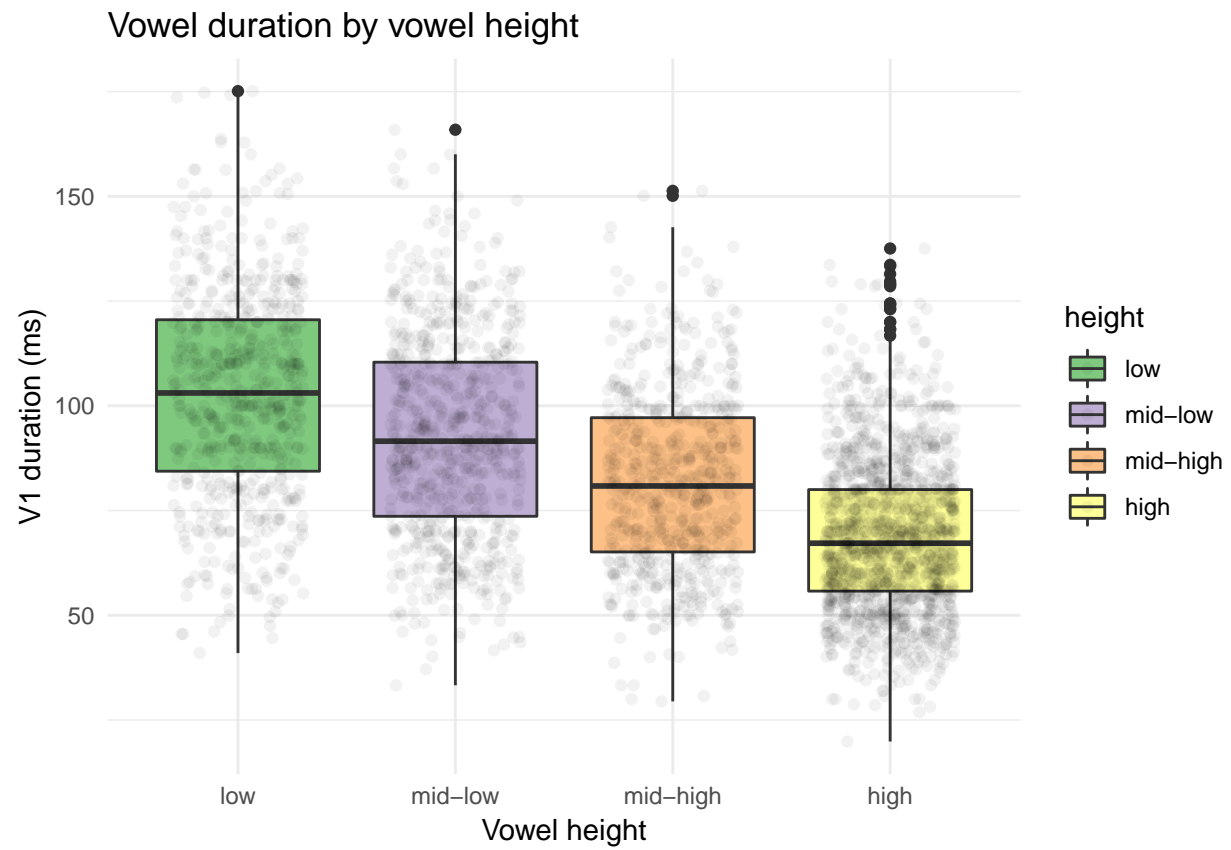
informative priors have been used: a normal distribution for the intercept with mean 50 and SD = 25, a normal distribution with mean 0 and SD = 20 for the estimates of C2 voicing and C2 place, and a normal distribution with mean 0 and SD = 25 for the by-speaker random intercept.

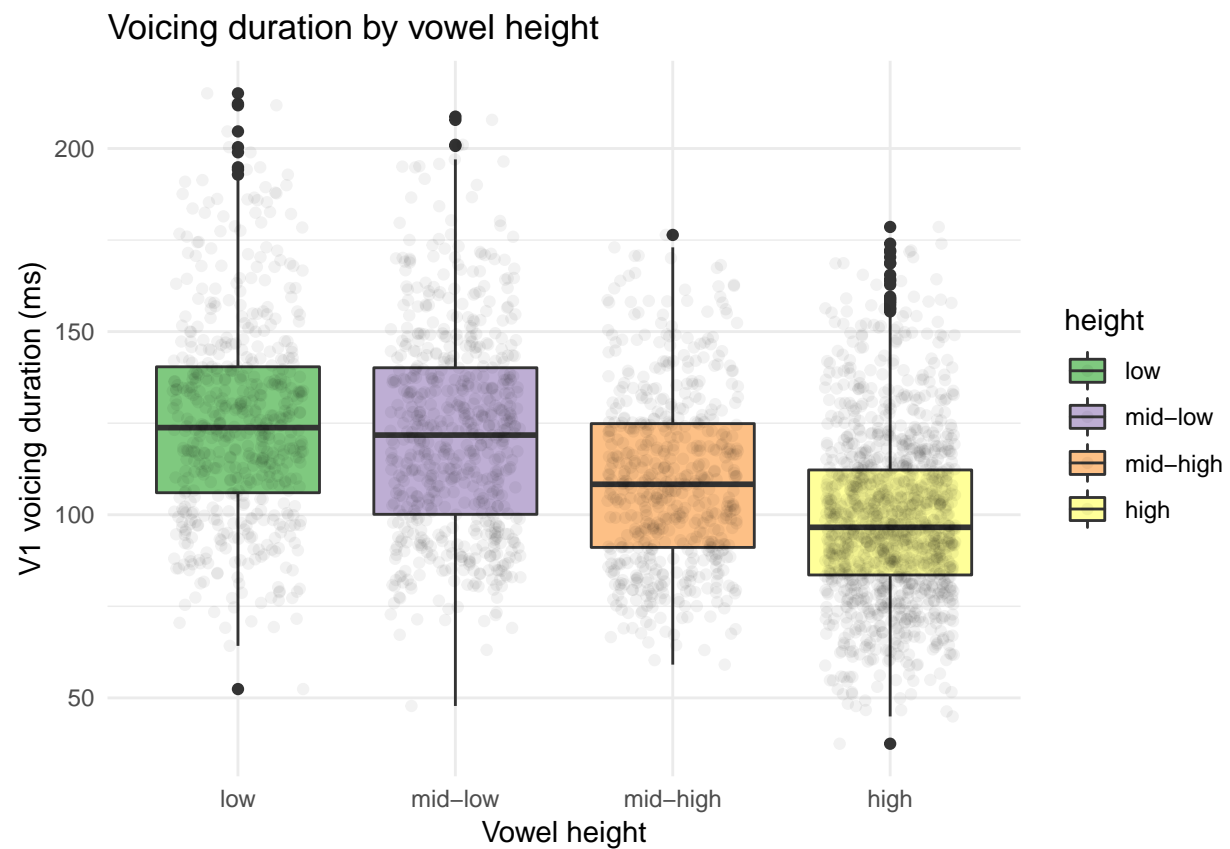
```
## Family: gaussian
## Links: mu = identity; sigma = identity
## Formula: v_duration | se(sd) ~ voice + place + (1 | speaker)
## Data: davis1989 (Number of observations: 18)
## Samples: 4 chains, each with iter = 2000; warmup = 1000; thin = 1;
##           total post-warmup samples = 4000
##
## Group-Level Effects:
## ~speaker (Number of levels: 3)
##           Estimate Est.Error l-90% CI u-90% CI Eff.Sample Rhat
## sd(Intercept)    22.17    10.04    10.41    42.27      1884 1.00
##
## Population-Level Effects:
##           Estimate Est.Error l-90% CI u-90% CI Eff.Sample Rhat
## Intercept        47.65     11.44     29.27     65.91      1446 1.00
## voicevoiced        6.32      3.01      1.37     11.22      3233 1.00
## placealveolar     -5.71      4.55    -13.19      1.79      2789 1.00
## placevelar        -9.76      2.95    -14.65     -4.95      3368 1.00
##
## Samples were drawn using sampling(NUTS). For each parameter, Eff.Sample
## is a crude measure of effective sample size, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).
```

The estimated effect of voicing is 6.32 ms with a 90% credible interval 1.37-11.22 ms. A credible interval indicates the range of values within which there is a given probability of finding the true estimate (a 90% credible interval says in which range there is a 90% probability that the true effect is contained within that interval). The following plot shows the posterior distributions of C2 voicing and place (the shaded areas are 90% credible intervals). The posterior distribution of the predictor C2 voicing suggest a small positive effect of voicing on unstressed vowel duration.



3 Italian EGG: vowel and voicing duration





References

Davis, Stuart & W Van Summers. 1989. Vowel length and closure duration in word-medial VC sequences. *The Journal of the Acoustical Society of America* 17. 339–353. doi:10.1121/1.2026892.