

Processing EGG data: New methods for a multidimensional time-series assessment of vocal fold activity

Stefano Coretta

The University of Manchester

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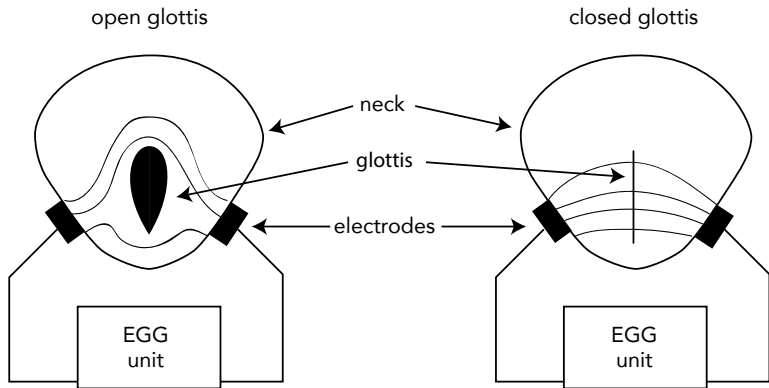
Background: Electroglottography

- EGG (Fabre, 1957; Scherer & Titze, 1987; Rothenberg & Mahshie, 1988)
 - estimation of vocal folds contact area (VFCA) based on impedance of high frequency current
- non-invasive
- relatively simple signal

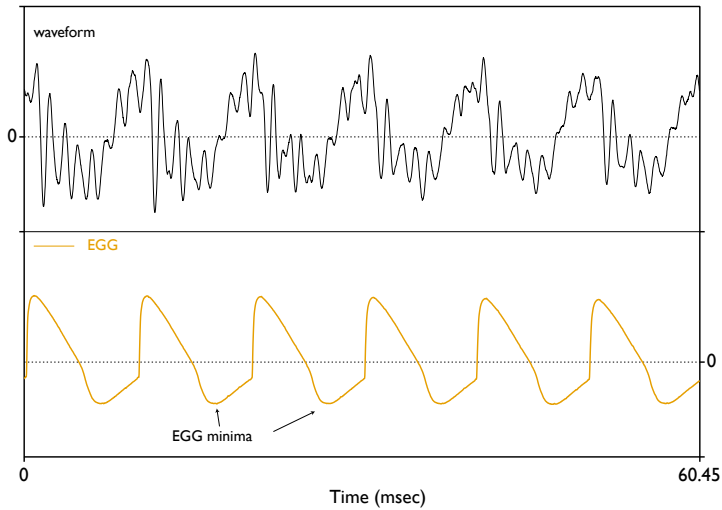
Background: Electroglottography



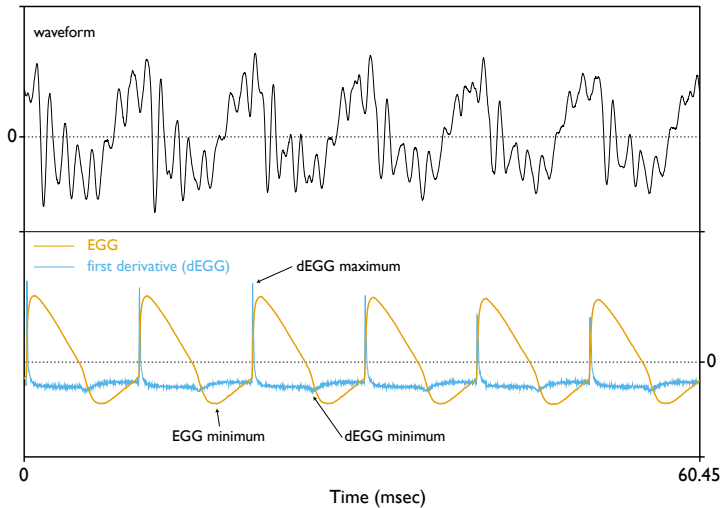
Background: Electroglottography



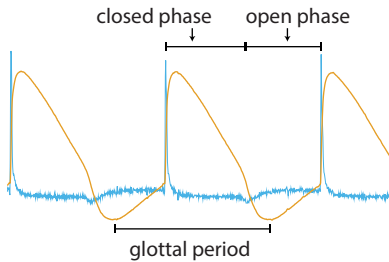
Background: EGG signal



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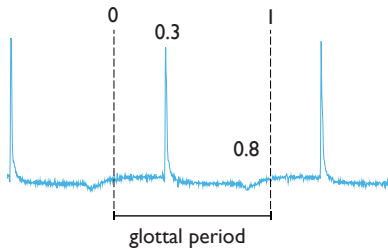


Background: EGG signal

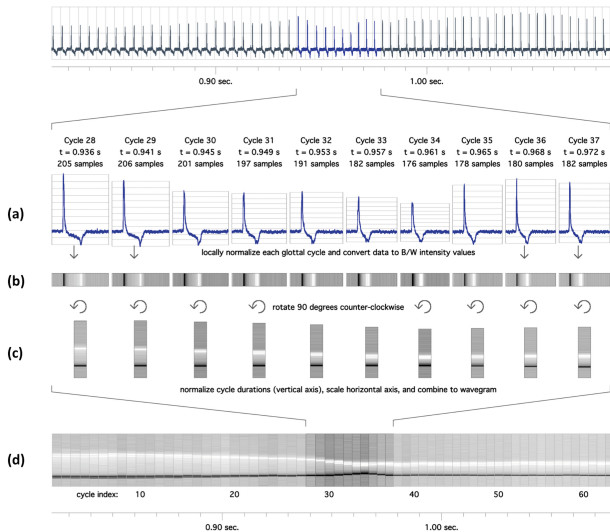


Background: Contact quotient

$$CQ = 0.8 - 0.3 = 0.5$$



Background: Wavegrams (Herbst et al., 2010)

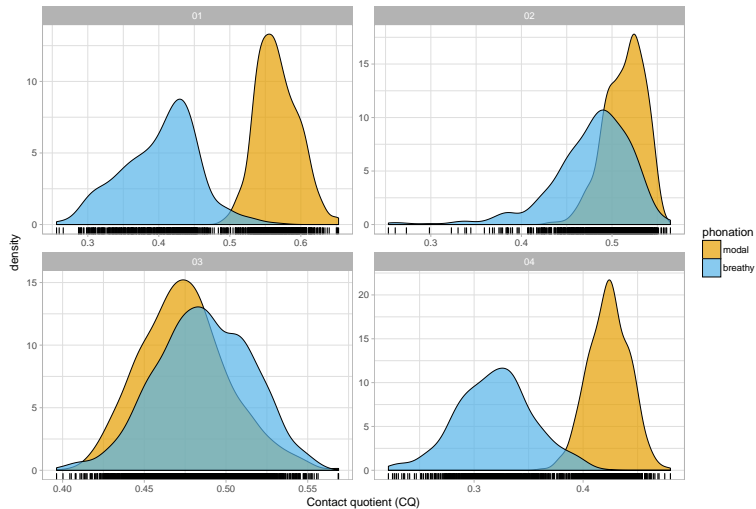


- 4 phonetically trained BE speakers (1 F, 3 M)
- [a] in modal and breathy voice
 - $10 \times 2 = 20$ tokens per speaker
 - 80 tokens
- equipment
 - Glottal Enterprises EG2-PCX2 unit
 - Movo LV4-O2 Lavalier microphone (sample rate 44100 Hz, 16-bit)

- 500 ms portion centered around mid point of each token
 - dEGG maxima and minima of each cycle within the 500 ms portion
 - CQ = minimum - maximum
 - wavegram data (Herbst et al., 2010)
- two new techniques
 - tracegram
 - waavegram generalised additive mixed models (GAMs)

Results: CQ

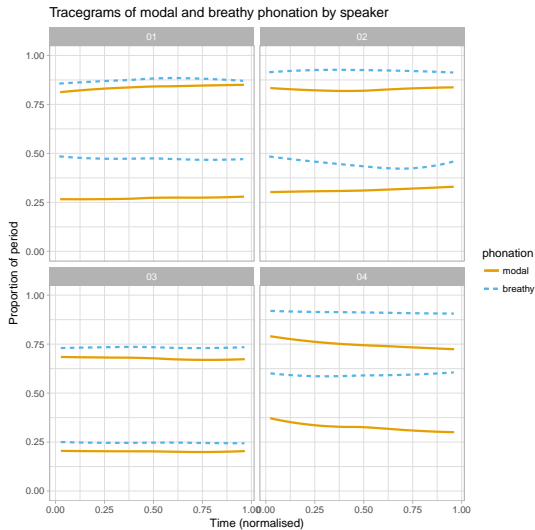
Density plots of CQ in modal and breathy phonation by speaker



Results: CQ

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: contact_quotient ~ phonation + (1 + phonation | speaker)
## Data: tracegram
##
## REML criterion at convergence: -19596.2
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -6.8237 -0.5875  0.0188  0.6320  5.0468
##
## Random effects:
## Groups   Name                Variance Std.Dev. Corr
## speaker  (Intercept)          0.003668 0.06057
##          phonationbreathy 0.005922 0.07696  -0.38
## Residual                    0.001081 0.03289
## Number of obs: 4927, groups: speaker, 4
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)    0.49460    0.03029  2.99979   16.33  0.0005 ***
## phonationbreathy -0.07312    0.03849  3.00022   -1.90  0.1537
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr)
## phontnbrthy -0.381
```

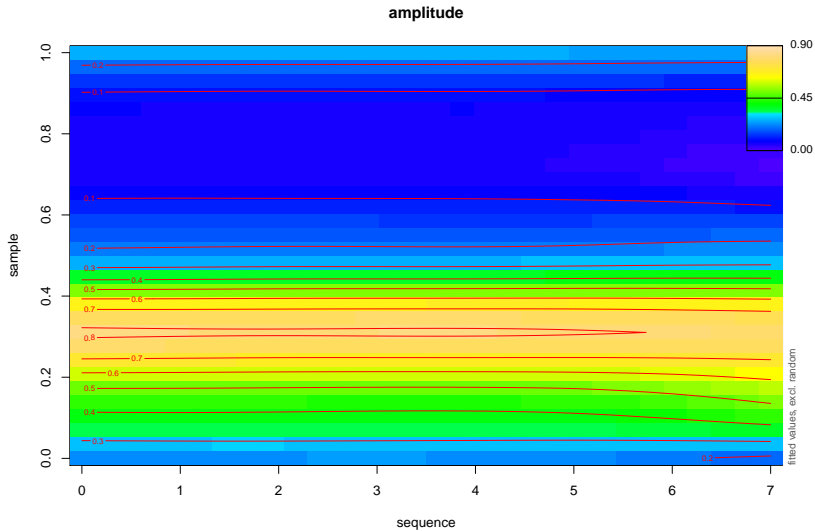
Results: Tracegram



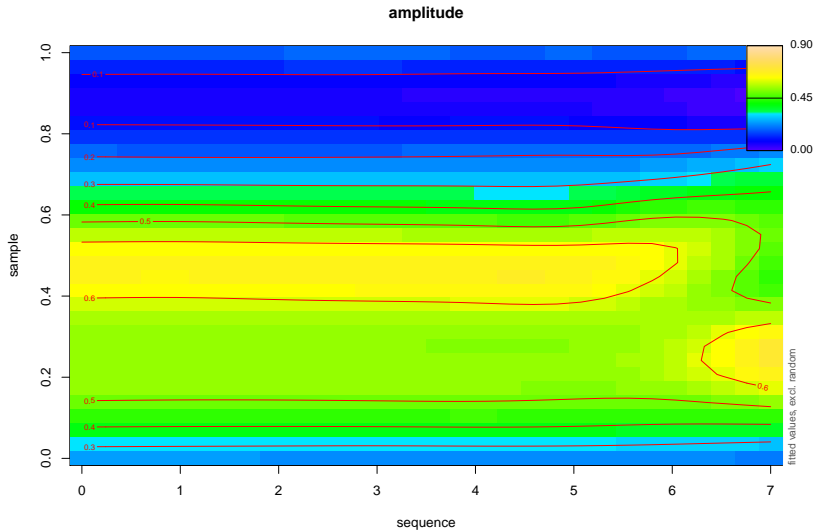
Results: Wavegram GAM

- generalised additive mixed models (Wood, 2006; Sóskuthy, 2017; van Rij et al., 2017)
 - non-linear multidimensional data
- statistical testing of wavegram data
 - heatmap plots: time, period, amplitude

Results: Wavegram GAM (modal)



Results: Wavegram GAM (breathy)



Results: Wavegram GAM

```
## phonation_gam_null: amplitude ~ s(sequence, k = 8) + s(sample) + ti(sequence, sample,
##    k = 8) + s(sequence, speaker_phon, bs = "fs", m = 1, k = 8)
##
## phonation_gam: amplitude ~ phonation + s(sequence, k = 8) + s(sample) + s(sequence,
##    by = phonation, k = 8) + s(sample, by = phonation) + ti(sequence,
##    sample, k = 8) + ti(sequence, sample, by = phonation, k = 8) +
##    s(sequence, speaker_phon, bs = "fs", m = 1, k = 8)
##
## Chi-square test of ML scores
## ----
##           Model      Score Edf Difference    Df  p.value Sig.
## 1 phonation_gam_null -35494.38  10
## 2   phonation_gam -53510.10  18  18015.719 8.000 < 2e-16 ***
##
## AIC difference: 36184.73, model phonation_gam has lower AIC.
```

- CQ performed badly for speaker 03
- Tracegrams
 - non-resource-intensive method for visualising fold activity
- Wavegram GAMs
 - assessing fold activity data statistically

References

Fabre, P. 1957. Un procede electrique percutane d'inscription de l'accolement glottique au cours de la phonation: glottographie de haute frequence. Premiers resultats. *Bulletin de l'Académie nationale de médecine* 141. 66.

Herbst, Christian T., W. Tecumseh S. Fitch & Jan G. Švec. 2010. Electroglottographic wavegrams: A technique for visualizing vocal fold dynamics noninvasively. *The Journal of the Acoustical Society of America* 128(5). 3070–3078.

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