The University of Manchester

Quantifying vocal fold activity: two new methods for analysing electroglottographic data

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New developments in speech sensing and imaging, Lisbon, 23rd June 2018

Background: The technique

- EGG (Fabre, 1957; Scherer & Titze, 1987; Rothenberg & Mahshie, 1988)
- **Purpose**: estimation of vocal folds contact area (VFCA)
- **How**: based on modulations of a current that travels the neck generated by the opening and closing of the vocal folds

Background: The technique

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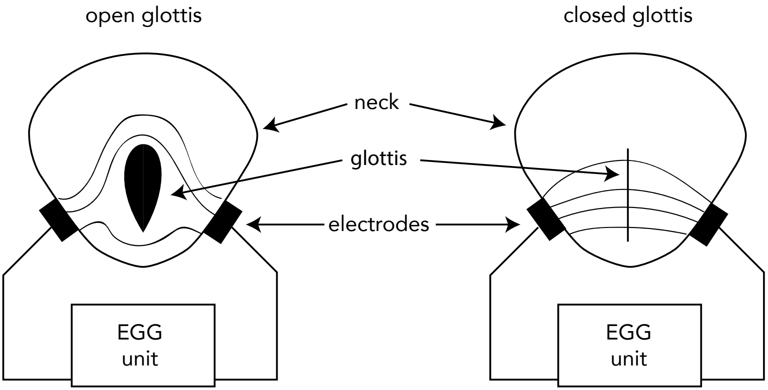
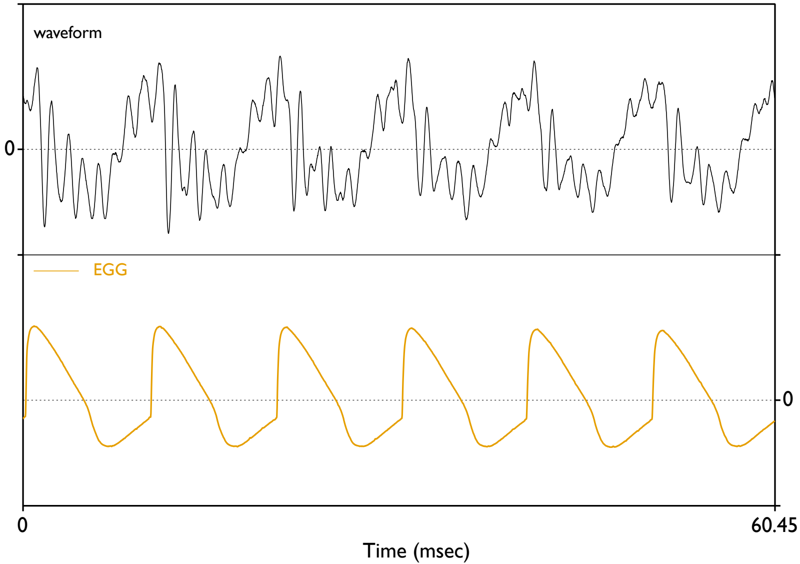


Background: The technique



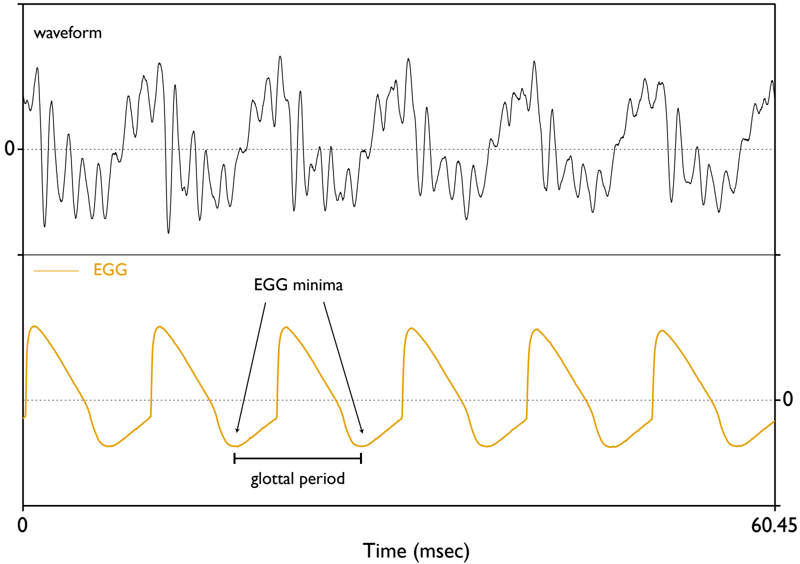
Background: The technique

- Pros:
  - non-invasive
  - relatively simple signal
- Cons:
  - approximantion of VFCA (Herbst et al., 2014; Hampala et al., 2016)
- Use:
  - estimation of vocal fold activity
  - estimation of fundamental frequency
  - study of pathological speech

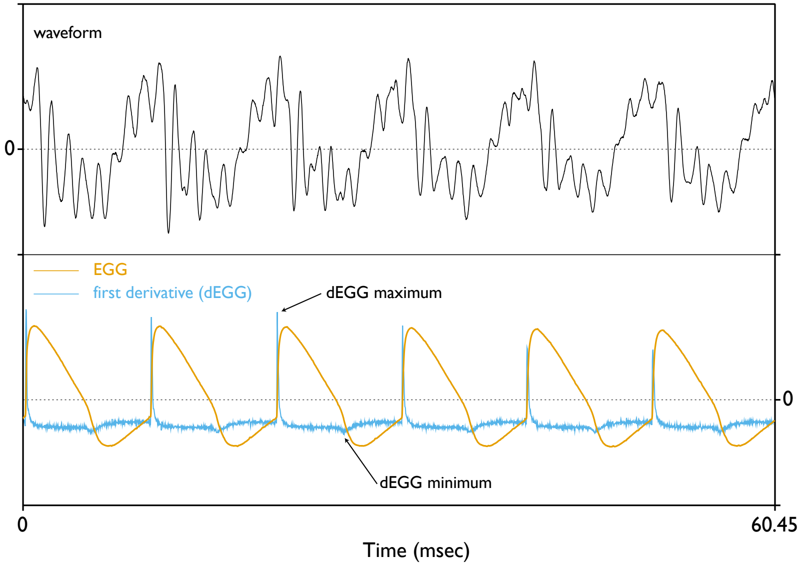
Background: The signal

- Contact Quotient (Awan et al., 2015; Herbst et al., 2017)
    - proportion of the contact phase relative to the glottal period
- Wavegram (Herbst et al., 2010)
    - visualisation of amplitude changes in the signal through time

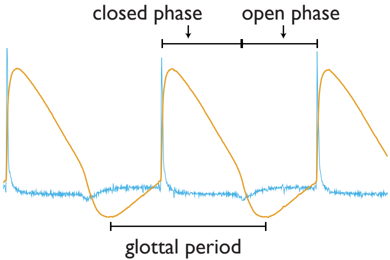
Background: The signal



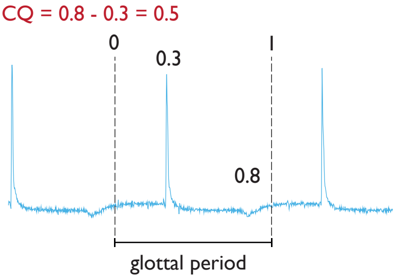
Background: The signal



Background: The signal



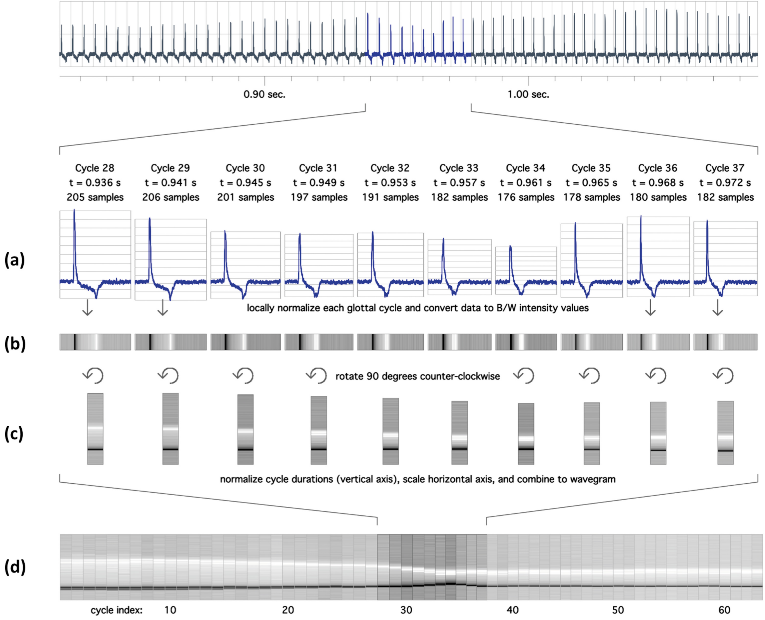
Background: The signal



Background: The signal

- CQ reduces dimentionality of EGG signal
- Herbst et al. (2010) propose the **wavegram** as a multidimentional account of the EGG signal

Background: The signal



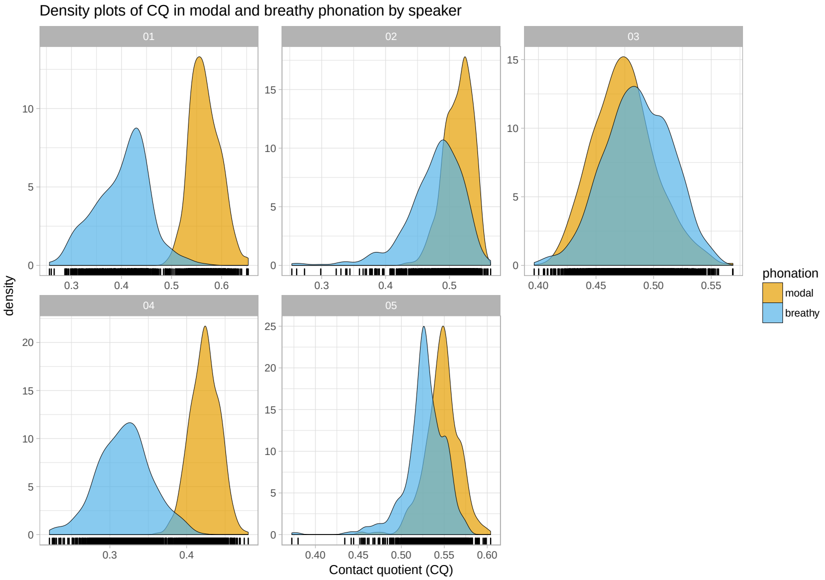
Background: This study

- Assessment of previous methods
    - CQ is not precise (Baken, 1992; Herbst et al., 2017)
    - wavegram cannot be assessed statistically
- Two new techniques
    - wavegram GAMs
    - tracegram

Methods

- 5 phonetically trained speakers (1 F, 4 M, languages: BE, IT)
- [ɑ]/[a] in modal and breathy voice
  - 10 × 2 = 20 tokens per speaker
  - 100 tokens
- equipment
  - Glottal Enterprises EG2-PCX2 electroglottograph
  - Movo LV4-O2 Lavalier microphone (sample rate 44100 Hz, 16-bit)
- analysis window
  - 500 ms portion centred around mid point of each token

Results: Contact Quotient (CQ)



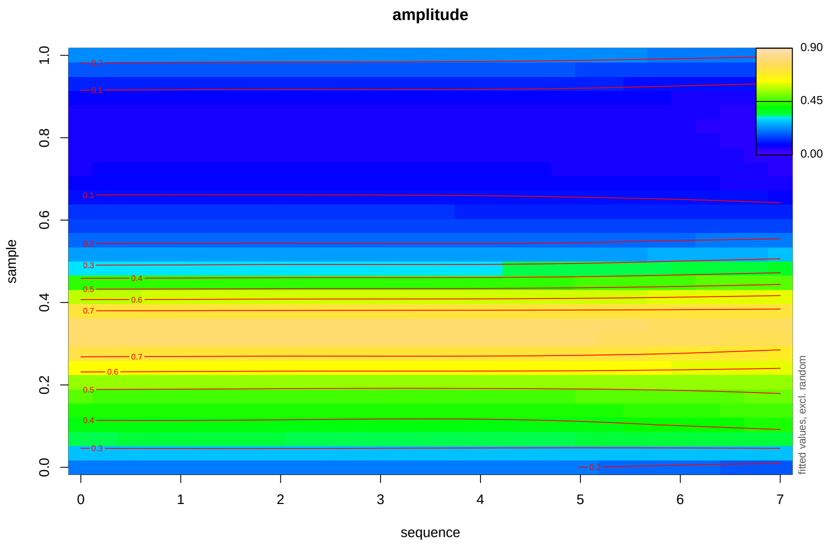
Results: Contact Quotient (CQ)

```
## 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: -24474.4
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -7.1831 -0.5597  0.0237  0.6202  5.3121
##
## Random effects:
##  Groups   Name             Variance Std.Dev. Corr
##  speaker  (Intercept)      0.003305 0.05749
##           phonationbreathy 0.005009 0.07077  -0.19
##  Residual                  0.000976 0.03124
## Number of obs: 5999, groups:  speaker, 5
##
## Fixed effects:
##                  Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)       0.50512    0.02572  4.00001  19.643 3.96e-05 ***
## phonationbreathy -0.06246    0.03166  3.99996  -1.973     0.12
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr)
## phontnbrthy -0.190
```

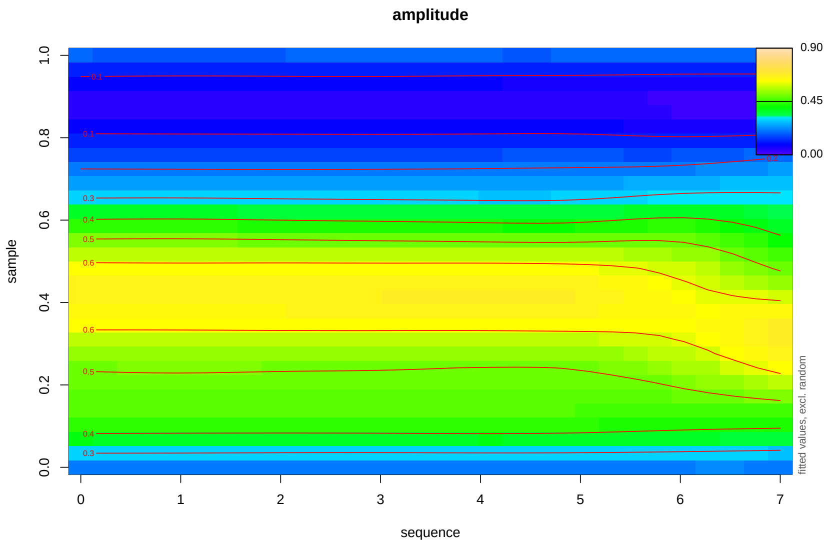
Results: Wavegram GAM

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

Results: Wavegram GAM (modal voice)



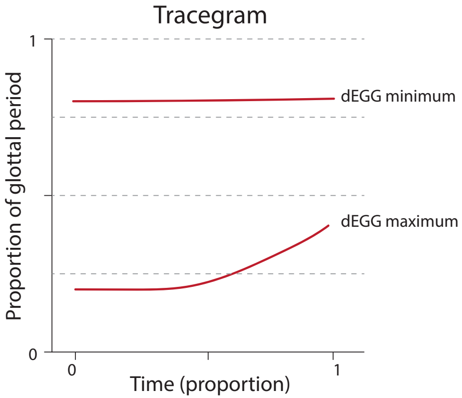
Results: Wavegram GAM (breathy voice)



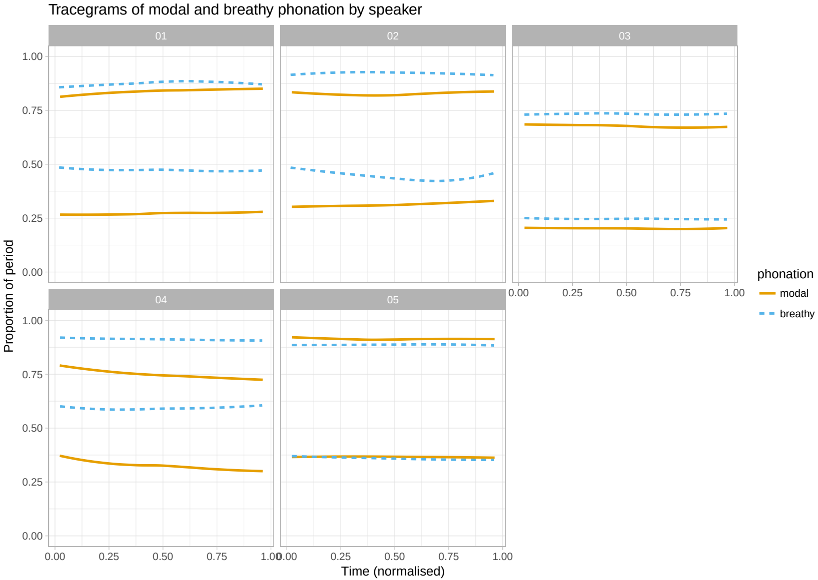
Results: Wavegram GAM

```
## 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 -53190.37  10
## 2      phonation_gam -66983.42  18  13793.050 8.000  < 2e-16  ***
##
## AIC difference: 27741.14, model phonation_gam has lower AIC.
```

Results: Tracegram



Results: Tracegram



Discussion

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

Thanks!

This project is funded by the School of Arts, Languages and Cultures at the University of Manchester. I would like to thank my supervisors, Ricardo Bermúdez-Otero and Patrycja Strycharczuk for the invaluable help and support, and all the members of the Phonetics Lab at the University of Manchester for the stimulating conversations about this project. All errors are my own.

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