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

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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

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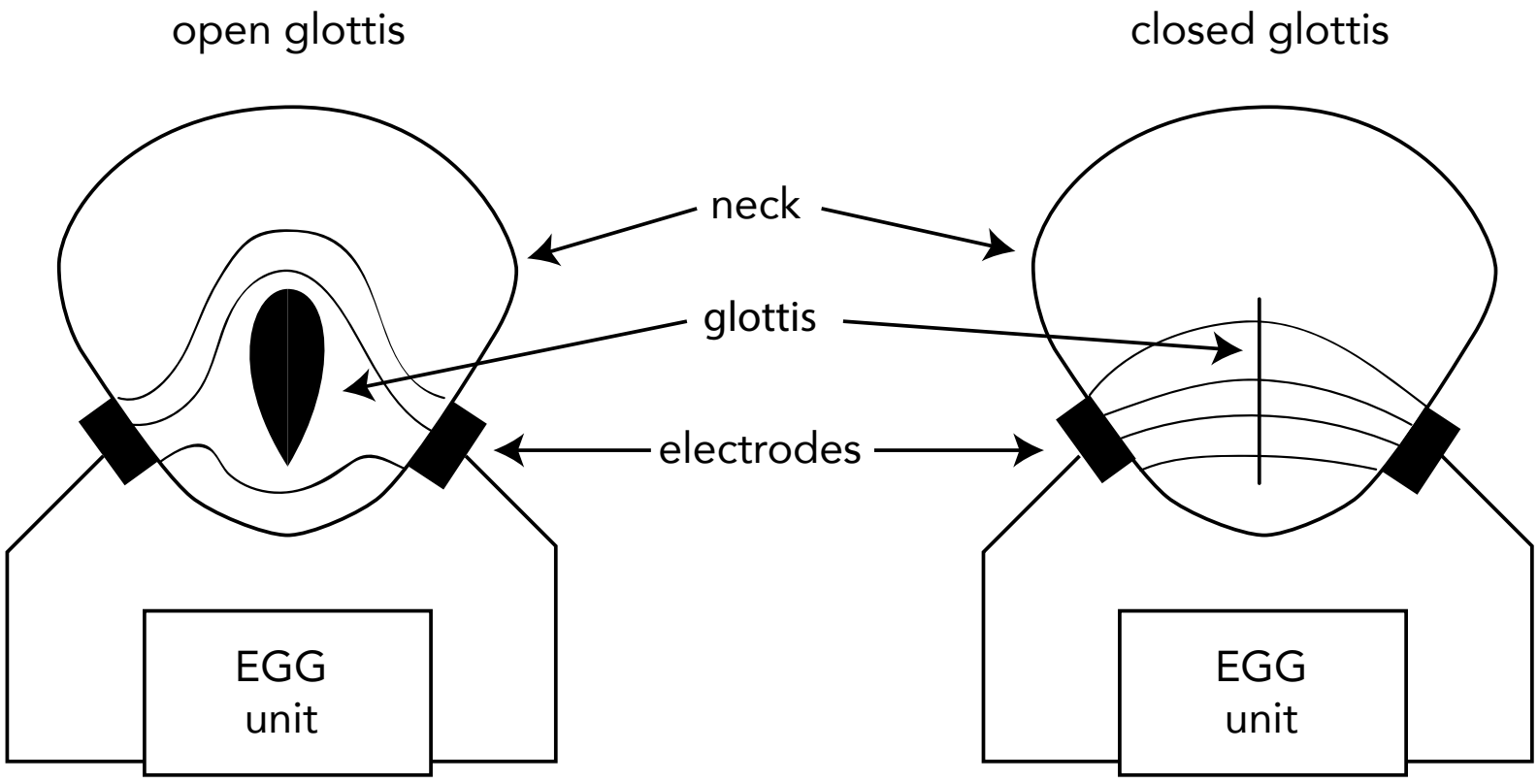
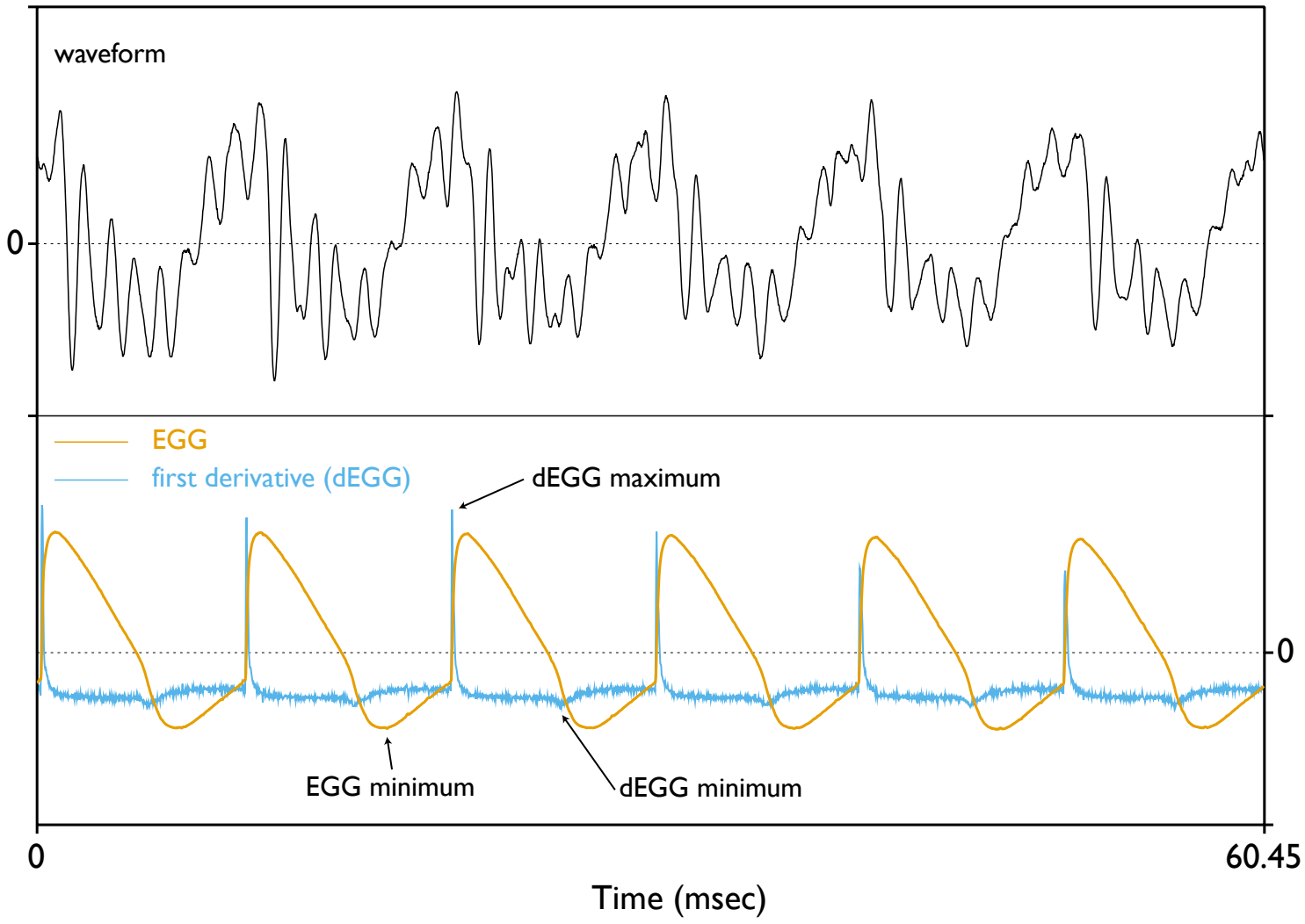
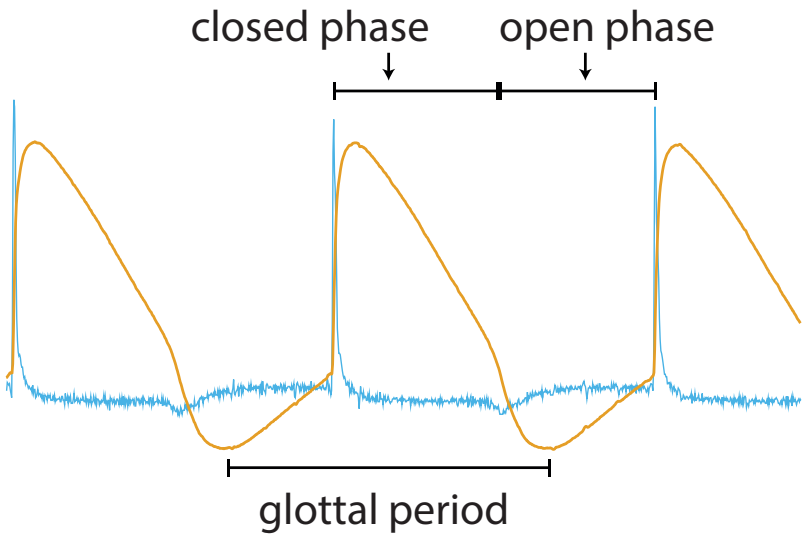


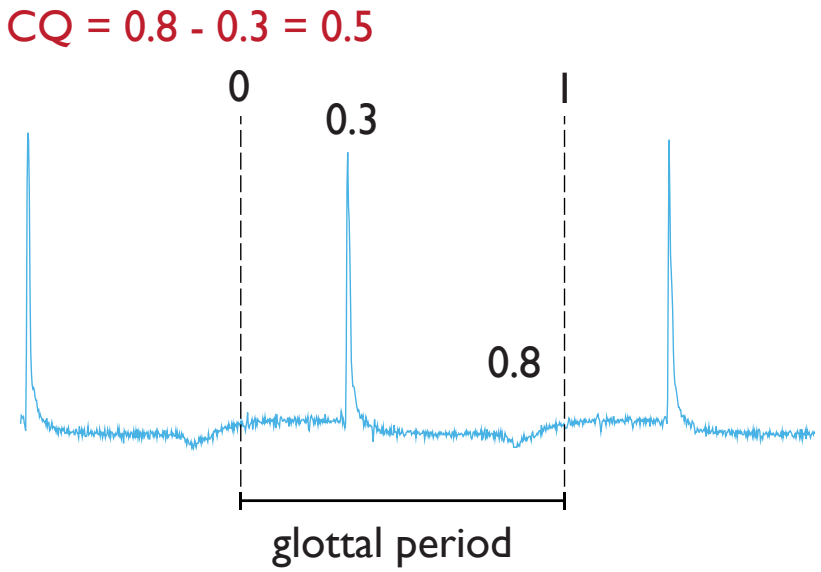
Background: EGG signal



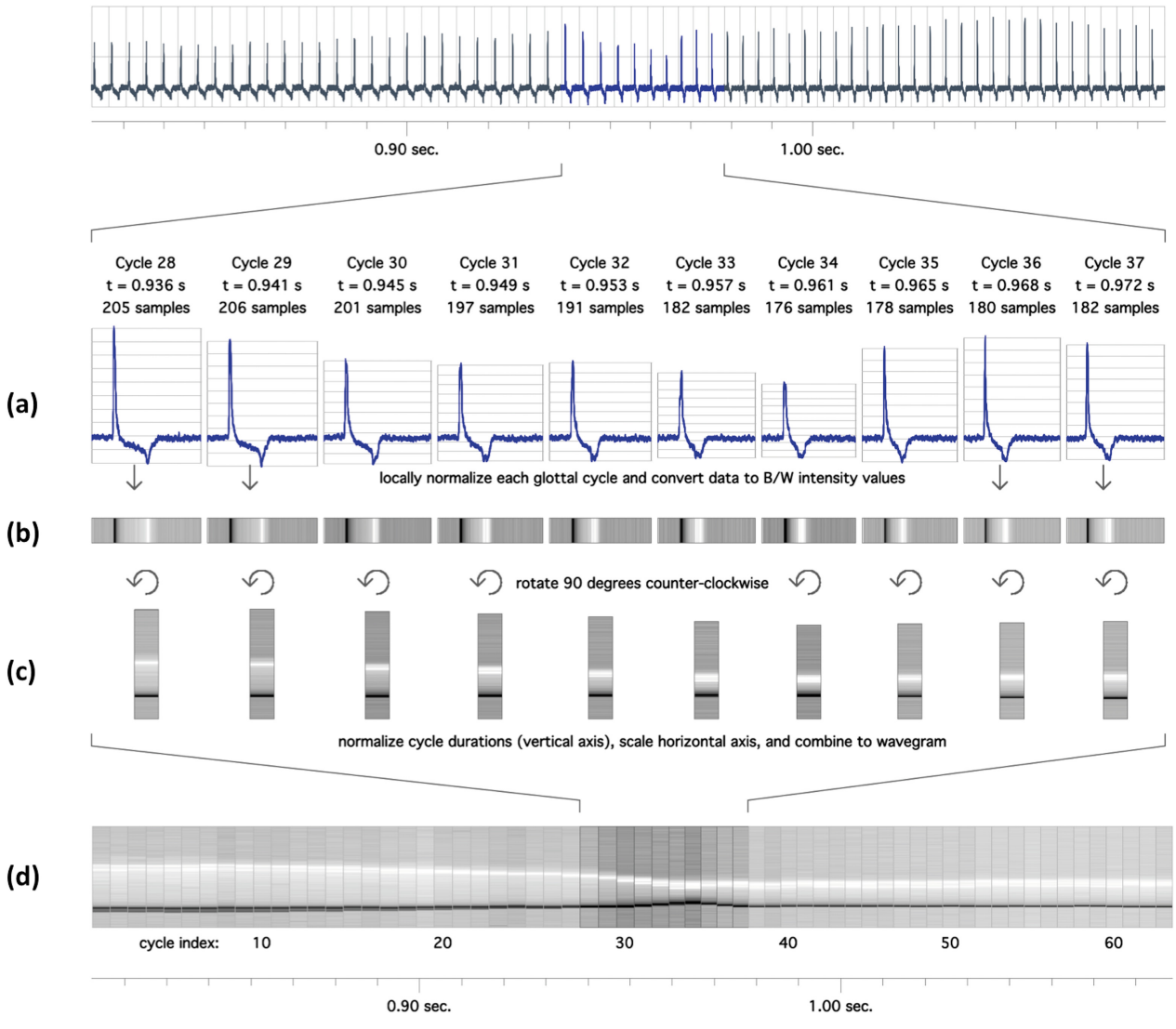
Background: EGG signal



Background: Contact quotient



Background: Wavegrams (Herbst et al., 2010)



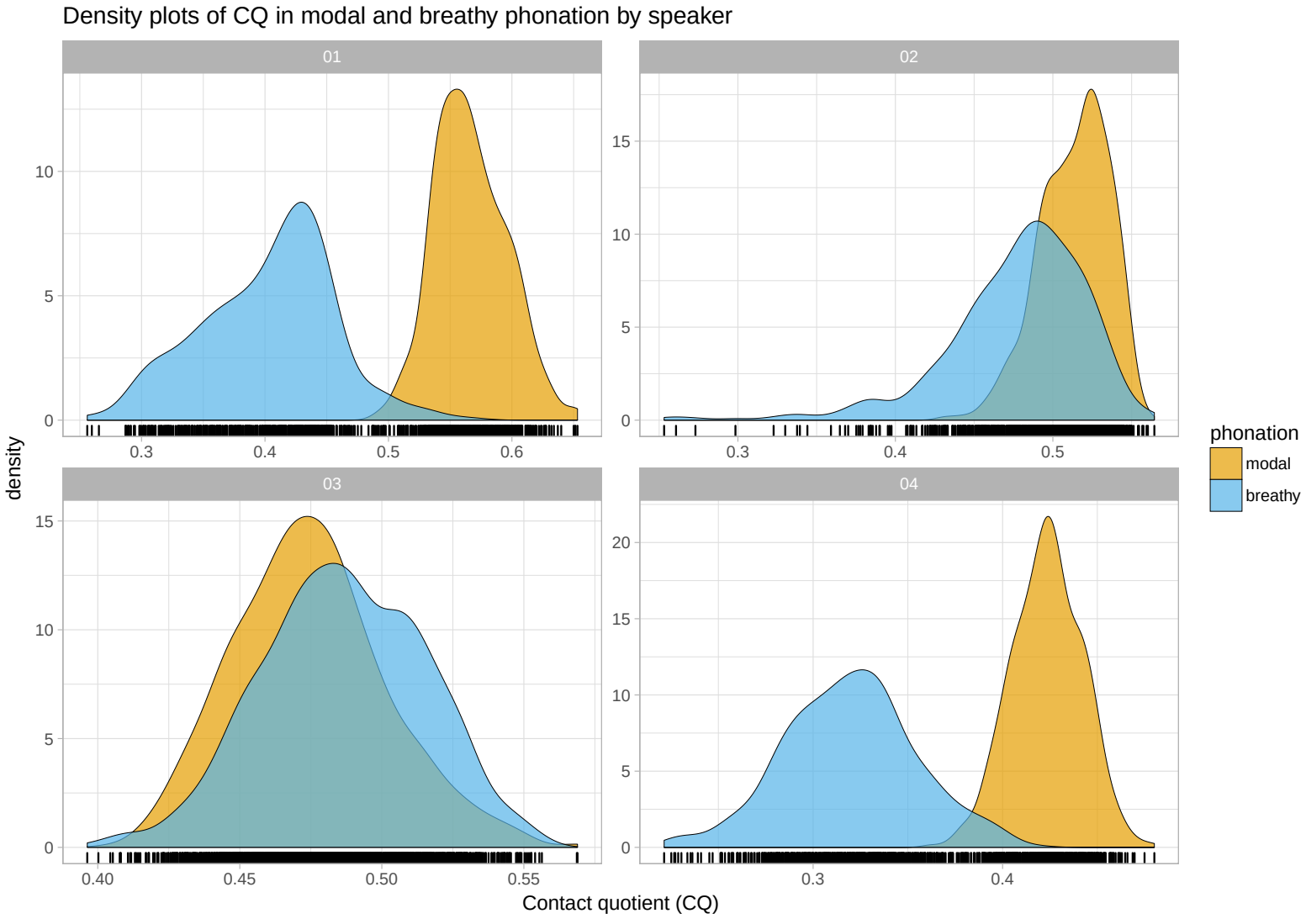
Methods

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

Methods

- 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
    - tracegram
- wavegram data (Herbst et al., 2010)
    - generalised additive mixed models (Wood, 2006; Sóskuthy, 2017; van Rij et al., 2017)

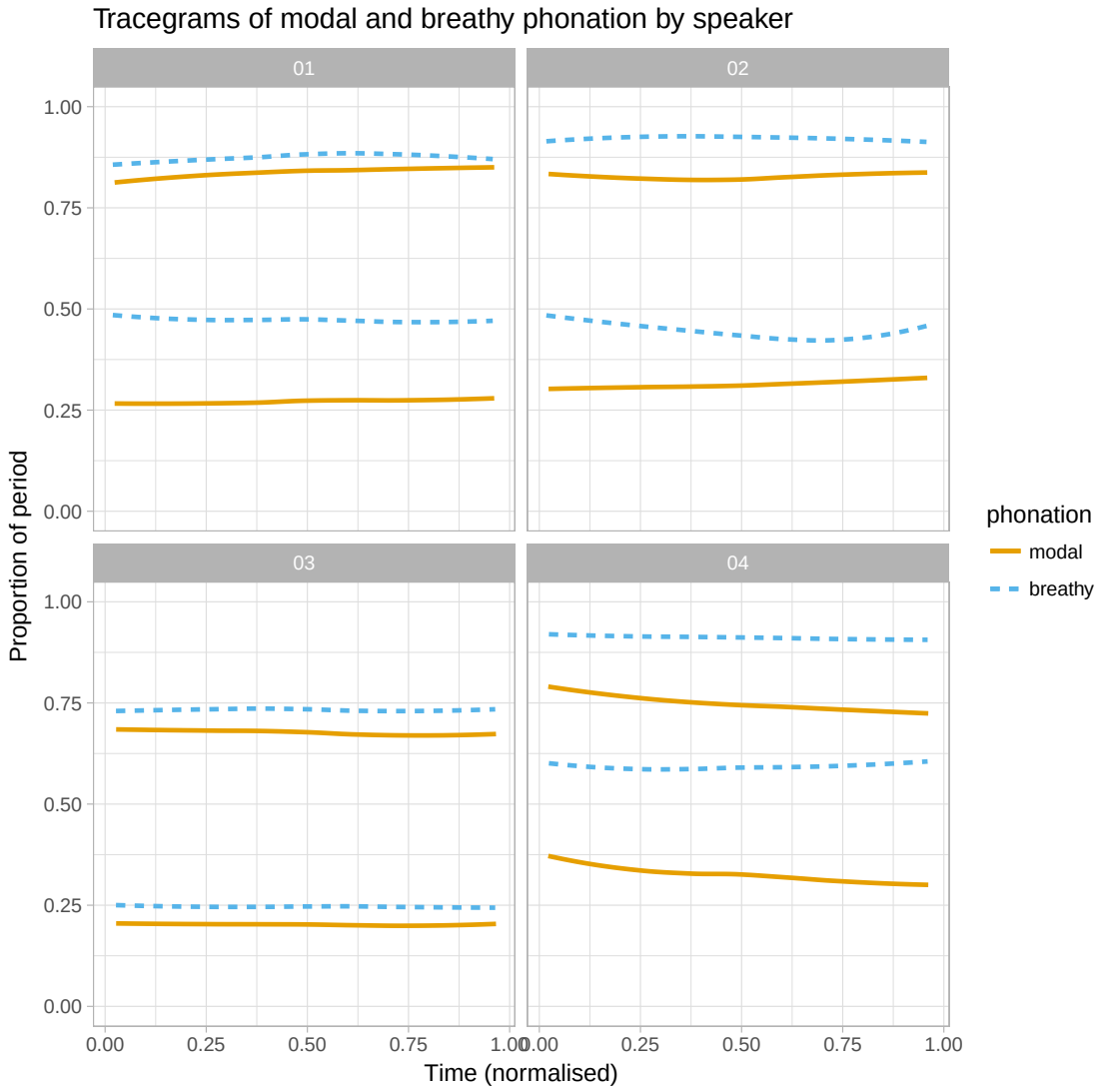
Results: CQ


Density plots of CQ in modal and breathy phonation by speaker
01
02
03
04
density
Contact quotient (CQ)
phonation
modal
breathy

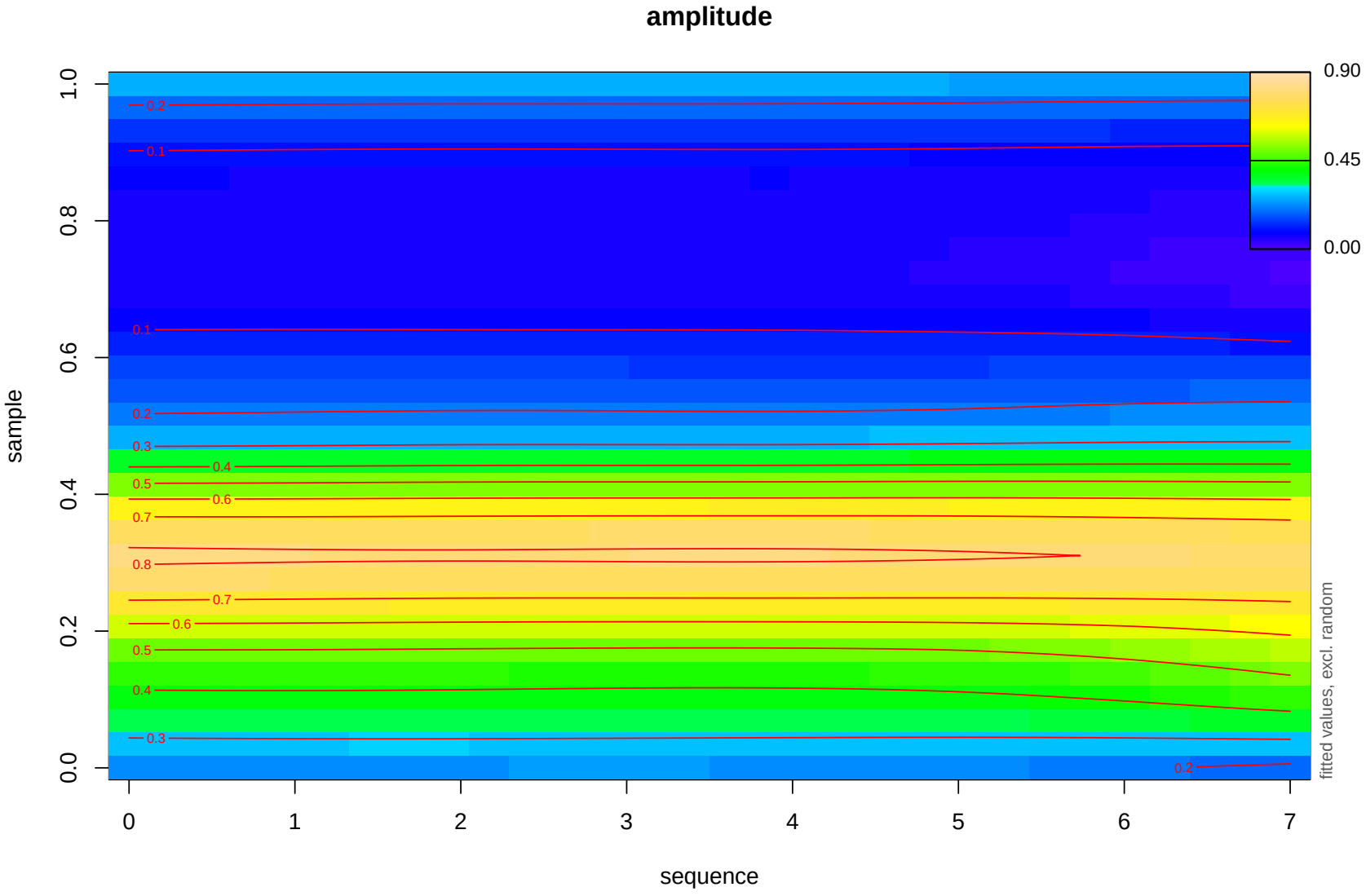
Results: CQ

```
## 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
```

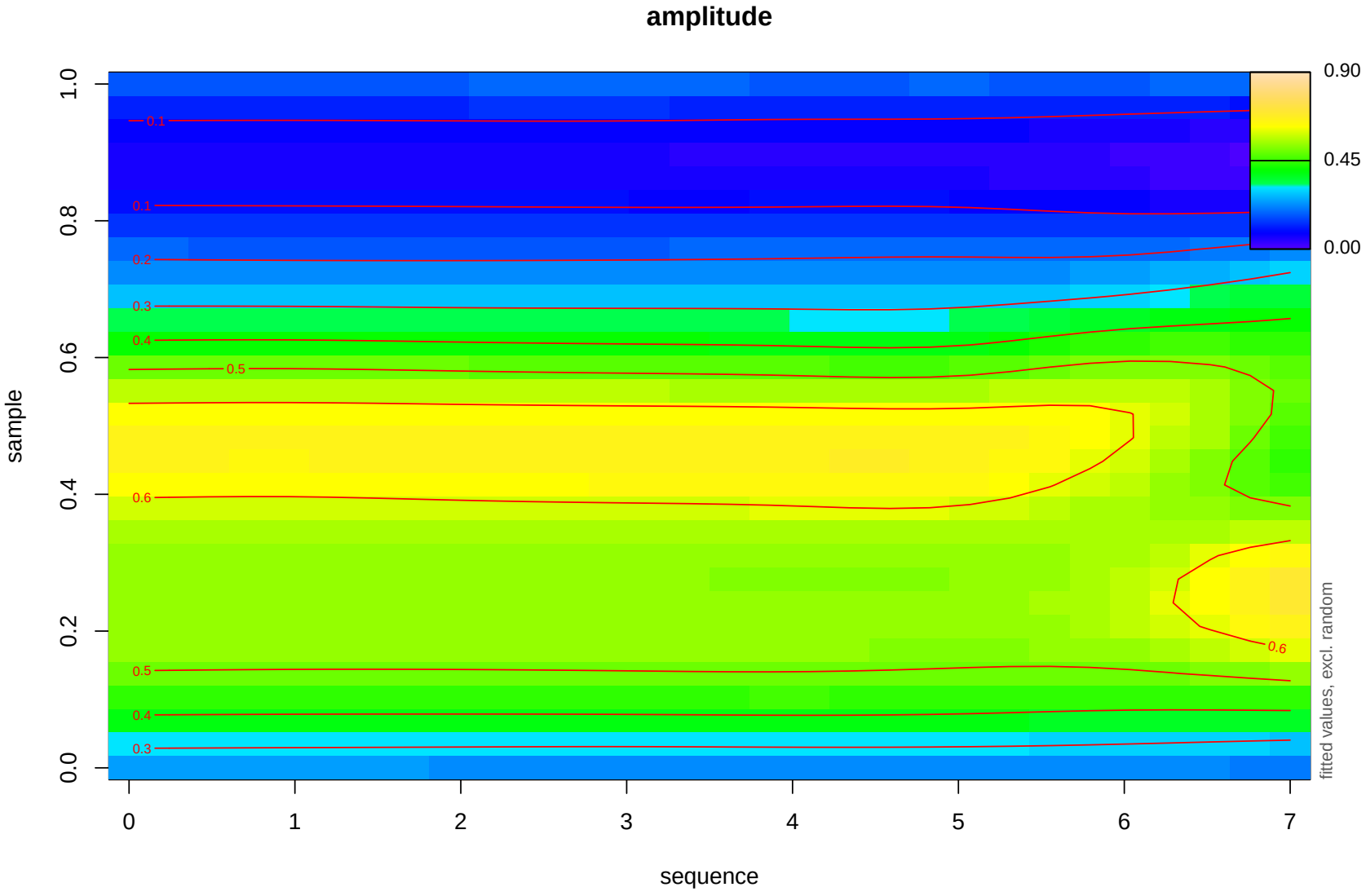
Results: Tracegram



Results: Wavegram GAM (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.
```

Discussion

- 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'inscrition 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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Scherer, Ronald C. & Ingo R. Titze. 1987. The abduction quotient related to vocal quality. *Journal of Voice* 1(3). 246–251.

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van Rij, Jacolien, Martijn Wieling, R. Harald Baayen & Hedderik van Rijn. 2017. itsadug: Interpreting time series and autocorrelated data using GAMMs. R package version 2.3.

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