# Analysis of Open Quotient in Voiced Fricative production using EGG

Cátia M. R. Pinho[1], Luis M.T. Jesus[2], Anna Barney[3]

[1] IEETA, Universidade de Aveiro, Portugal; [2] IEETA and ESSUA, Universidade de Aveiro, Portugal; [3] ISVR, University of Southampton, UK

catiap@ua.pt, lmtj@ua.pt, ab3@soton.ac.uk

ieeta instituto de engenharia electrónica e telemática de aveiro

University of Southampton Institute of Sound and Vibration Research

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## Introduction

- The **objective** of this **study** was to characterise the electroglottography (EGG) signal based parameter Open Quotient (OQ), during fricative production, and during the phones preceding and following the fricative in a carrier phrase.
- We aim to quantitatively establish if the relatively weak voicing during the fricative production may be differentiated from the stronger voicing of the contextual vowel.
- Our long term goal is to understand the mechanisms by which voicing is initiated and maintained as a guide to improving strategies for initiating and maintaining voicing in patients with laryngeal impairment such as unilateral vocal fold paralysis (UVFP) [1].

## Method

- Data were collected from 4 healthy adult speakers (2♀ and 2♂) producing a speech corpus of 9 isolated words with the European Portuguese (EP) voiced fricatives /v, z, Z/ in initial, medial and final word position, embedded in 42 different real EP carrier sentences. (VFV sequences were analysed)
- To analyse the EGG signal we built *Matlab* scripts based on the open source software *MOQ interface* [2-3]. We used the method "DEGG DECOM", reported as the one that presented the best results when compared to OQ measurements derived from the inverse-filtered glottal flow [3].
- These functions, developed for the singing voice [3], assume a quasi-periodic signal and were therefore considered to be suitable for voiced fricative analysis.
- We also derived the OQ using *Matlab* scripts based on the *peakdet* approach [2] (reported as more suitable for speech [2], including rapid changes in voice quality).
- To characterise the fricatives in terms of their production mechanisms, OQ derived from the EGG signal during the steady state of the fricative and of the adjacent vowels was analysed.
- The strategy used to correlate and extract information from these different modes of speech production was based on average values calculated for the OQ within phone1 (vowel), phone2 (fricative) and phone3 (vowel), as shown in Fig. 1.

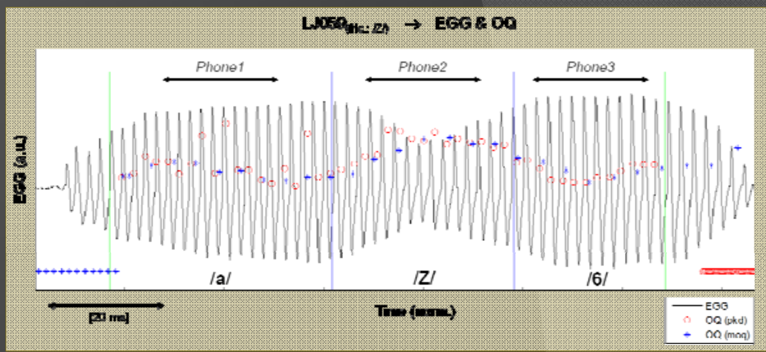


Fig. 1: Normalised EGG signal. The strategy used to correlate and extract information on these different stages of speech production was based on the average of OQ values calculated from 20 ms windows centred within Phone(1, 2, 3), in order to characterise the steady state of fricative production, relative to adjacent phones.

## Results

- For male data, an increase in the OQ values during fricative production (phone2) was observed when compared to OQ values from the adjacent vowels (phone1 and phone3), while for female the OQ values during the fricative production decreased or were approximately the same (see Table 1).

Table 1. Mean ± std absolute values of OQ (*MOQ interface*).

| OQ (%) | /v/ | | | /z/ | | | /Z/ | | |
|---|---|---|---|---|---|---|---|---|---|
| *phone* | *1* | *2* | *3* | *1* | *2* | *3* | *1* | *2* | *3* |
| ♂LJ | 51±4 | 63±6 | 54±6 | 50±3 | 61±7 | 51±6 | 49±4 | 69±8 | 53±7 |
| ♂RS | 52±6 | 66±10 | 55±6 | 53±13 | 58±8 | 54±7 | 63±16 | 69±7 | 62±9 |
| ♀JG | 56±6 | 41±24 | 52±7 | 55±5 | 38±22 | 52±5 | 57±10 | 35±29 | 55±7 |
| ♀HV | 49±9 | 62±17 | 50±4 | 44±6 | 57±19 | 57±10 | 50±7 | 56±21 | 54±7 |

- OQ derived from the *peakdet* approach didn't show major differences with the values extracted from the *MOQ interface* (see Fig. 1).
- However, an initial analysis revealed that the *peakdet* algorithm seems less reliable/robust.
- The number of samples that *peakdet* was able to extract the OQ parameter from, was less for female speakers than the *MOQ interface* method ( [*MOQ*: 96%, *peakdet*: 60%] of samples). For male speakers the opposite was observed but with a smaller difference ([*MOQ*: 81%, *peakdet*: 94%] of samples).

## Discussion

- There was a small increase in the OQ values during the fricative, relative to that of the adjacent vowels for male speakers . We can hypothesise that a more physically efficient voice is related with a decrease of the OQ value during the production of vowels [4].
- Changes observed in the EGG waveform during fricative production, thought to result from the rise in the supraglottal pressure due to a supraglottal constriction [5], may be useful in a definition of weak voicing [1].
- Females do not seem to use the same strategy as males, and female's higher f0 and smaller larynx sizes present an additional challenge for OQ detection from the EGG signal.
- OQ for different places of articulation: labio-dental (/v/ - [41-66]%) alveolar (/z/ - [38-61]%); postalveolar (/Z/- [35-69]%).

## Future work

- Further work is needed to relate these results to vocal fold mechanics.
- We plan to extract the OQ from the inverse-filtered glottal flow (a signal we simultaneously acquired during data collection) in order to extend our study of OQ to UVFP patients where EGG cannot be reliably collected.

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