STIFFNESS OF THE VOCAL FOLDS, A NEW CLINICAL PARAMETER TO EVALUATE THE QUALITY OF VOICE FUNCTION?

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The 11th International Conference on Advances in Quantitative Laryngology, Voice and Speech Research (AQL) 8th April 2015, London

High speed films

- Superior to clinical laryngo-stroboscopy in many areas of voice diagnostics

- Able to capture 4000 or more images per second

- Data is acquired with a high-speed camera recording in real-time during phonation of the vowel /a/. A rigid endoscope (90^0 optic, 9-mm diameter) is placed into the oropharynx coupled to a high-speed camera.

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Refined diagnoses of laryngeal disorders

Insted of stroboscopy:

- High speed films
- Kymography
- Phonovibrogram
- The prospects of calculation of "Stiffness"

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High speed endocam system

- With the High Speed Endocam system* there has been developed a software reproduction of the stiffness of single vocal fold movements with the Glottis Analysis Tools by M. Döllinger et al.

* Wolf Ltd. HRES Endocam 5562 analytic system (Richard Wolf GmbH, Pforzheimer Strasse 32, 75438 Knittlingen, Germany)
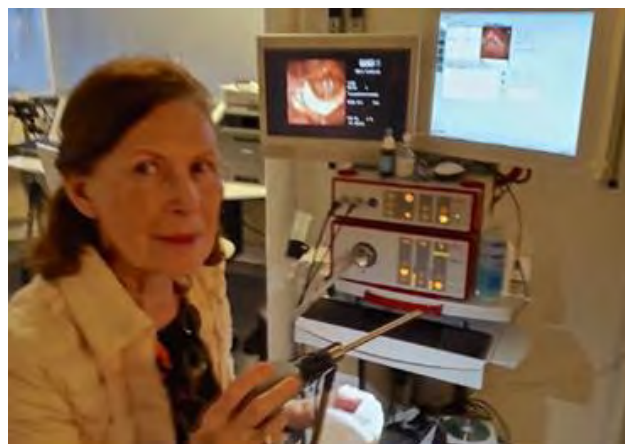
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High speed films

Segmentation of the open quotients are calculated in front – center – rear area – smaller in front between the vocal folds.

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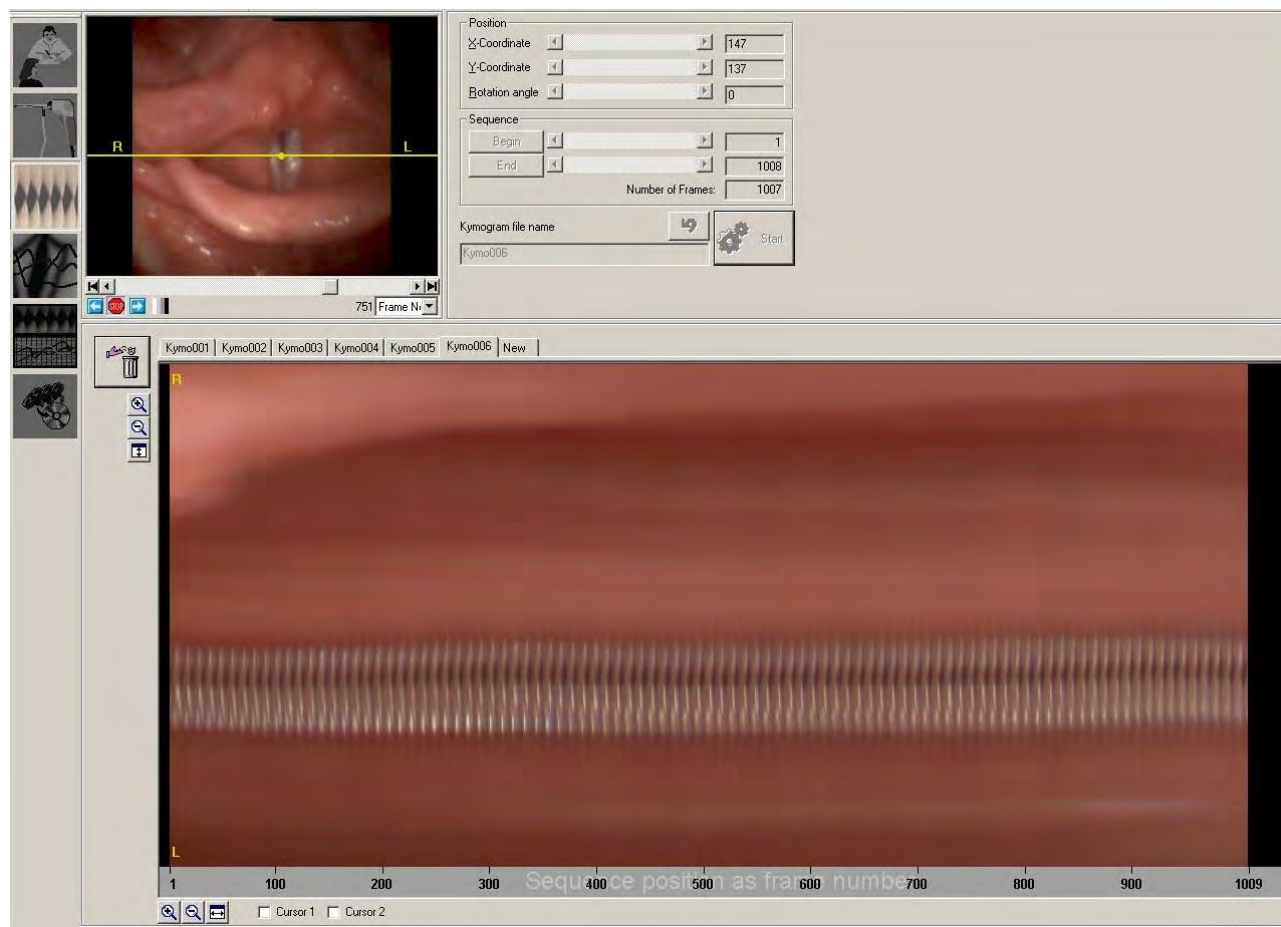Tel: +45 33 15 96 00; Fax: +45 33 13 77 05, E-mail: m.f.pedersen@dadlnet.dk

High speed films and kymography

Kymography
shows single
movement of
the vocal folds
from above
– here they are
regular

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High speed films and mean stiffness

Segmentation:
The setup for calculation of measurements of mean stiffness of the Glottal Area Wave form (GAW)
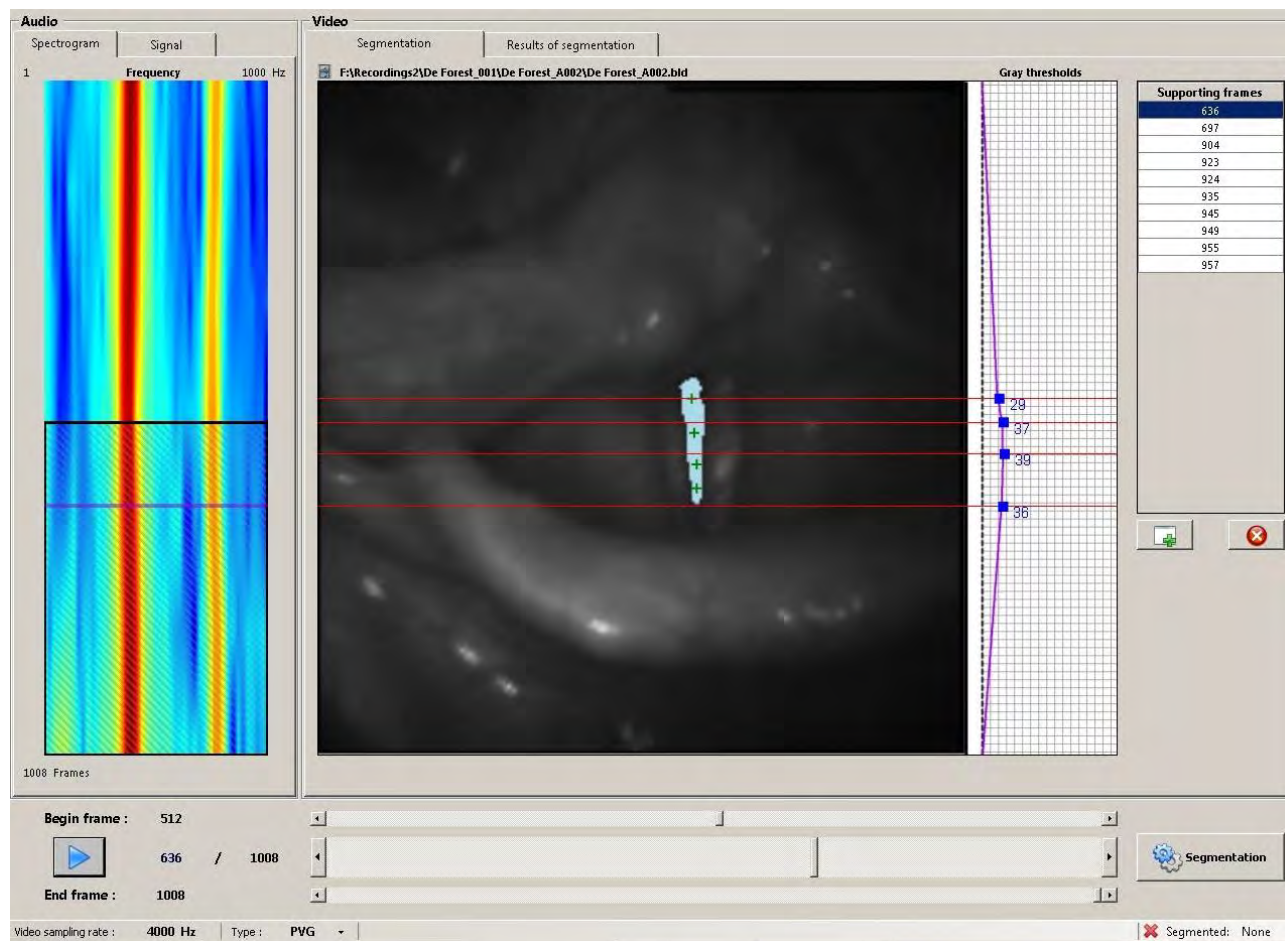
The formula for stiffness

$$Stiffness = \frac{max_{t \subset T_i}(s(t))}{A_i}$$

Where T_i is the duration of ith cycle in miliseconds (ms), A_i is the dynamic range (max-min) for i^{th} cycle and s(t) is the magnitude of the 1st derivative of considered signal for i^{th} cycle (t C T_i).

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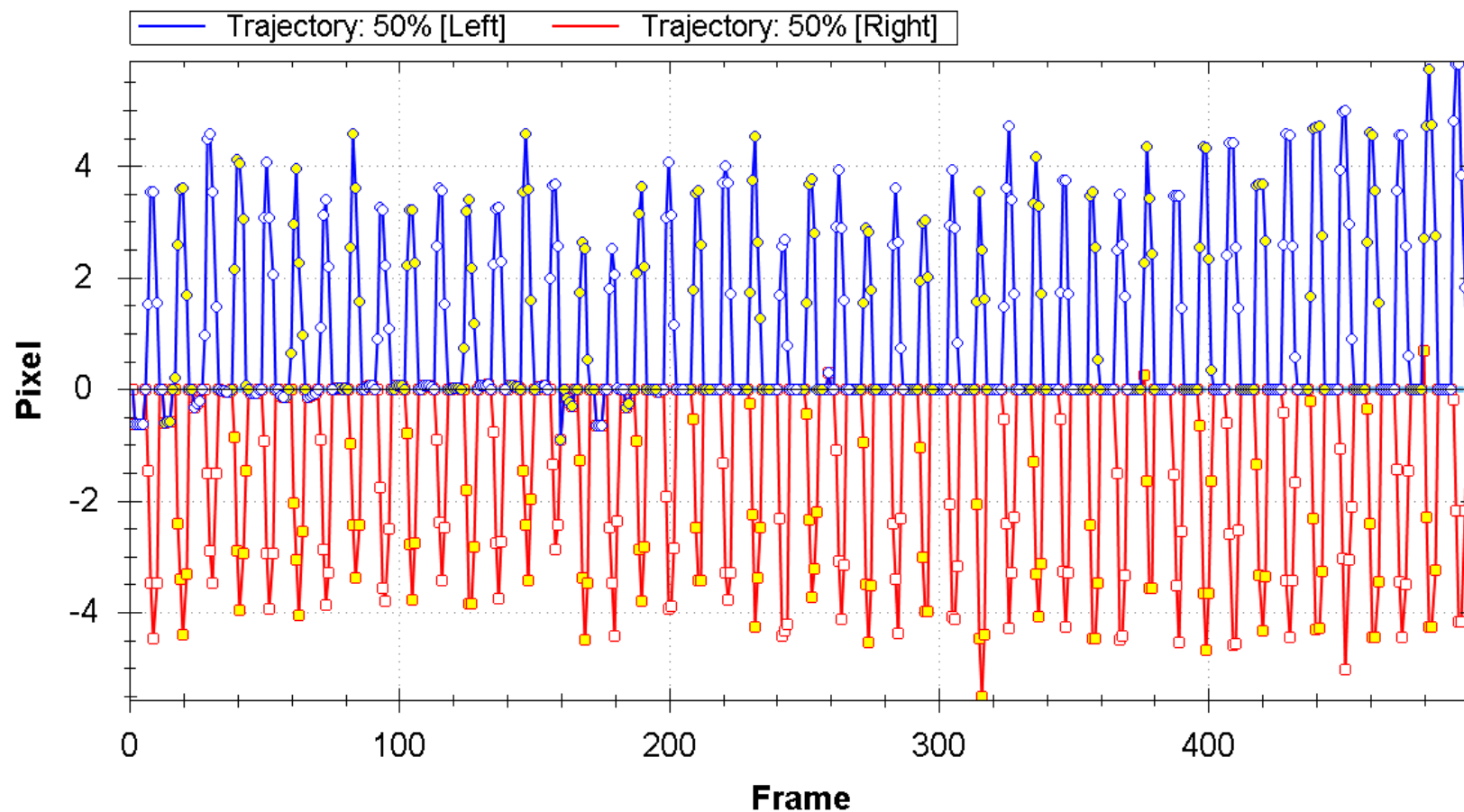Tel: +45 33 15 96 00; Fax: +45 33 13 77 05, E-mail:m.f.pedersen@dadlnet.dk

Difference in stiffness

- A difference in stiffness of the vocal folds is measured when comparing trained and non-trained voice users. The objective is to evaluate the new method based on software reproduction of the vocal fold movements, that is included in Glottis Analysis Tools used together with high speed films.

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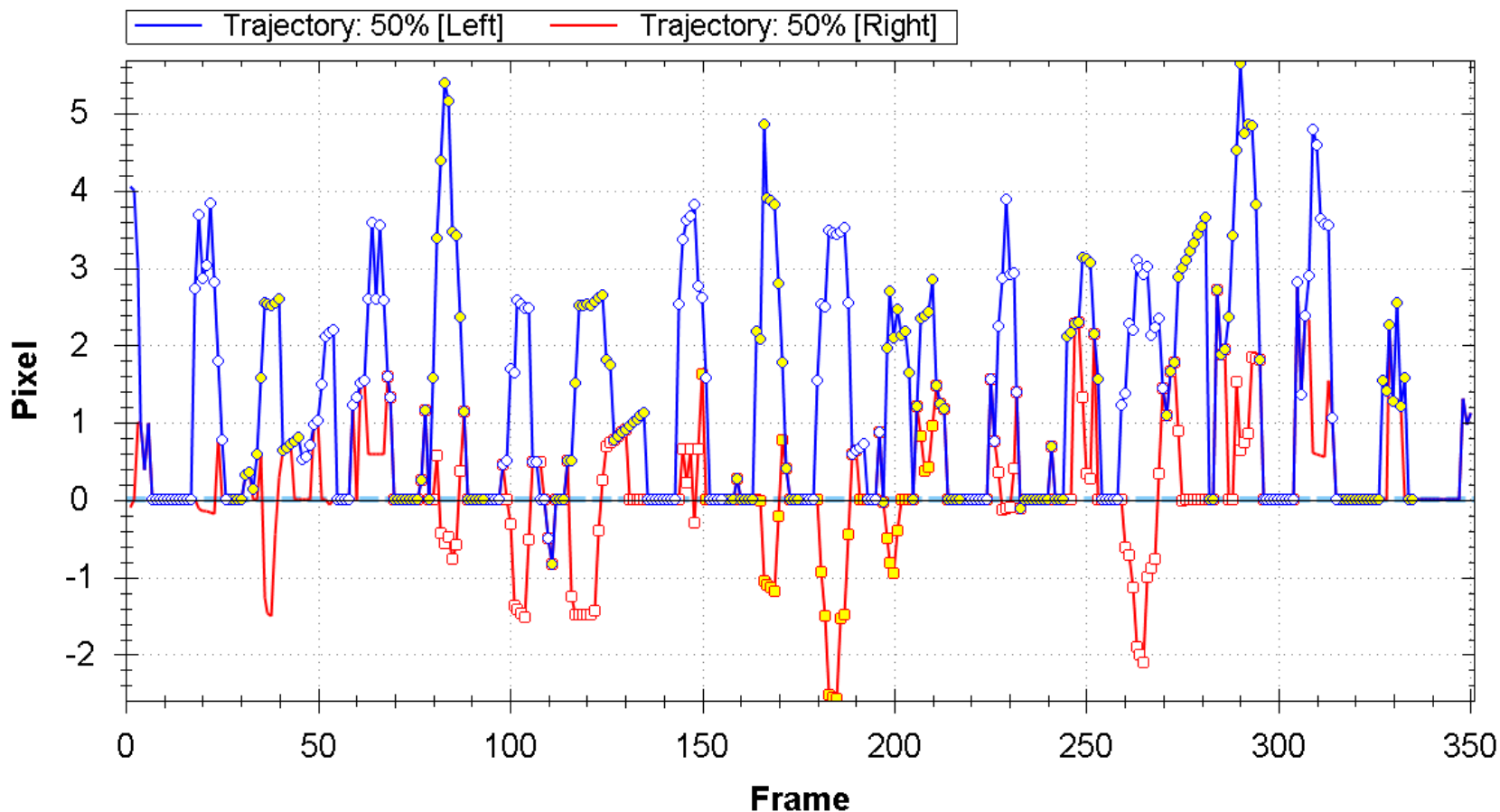Tel: +45 33 15 96 00; Fax: +45 33 13 77 05, E-mail:m.f.pedersen@dadlnet.dk

Trajectories

- Trajectories is like a kymogram
- The diagram shows the vocal cords in a 50% distance from the posterior border (therefor called [Traj-50%])

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Trajectories of a contest winning female

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Trajectories of a 59 years old male with acute laryngitis

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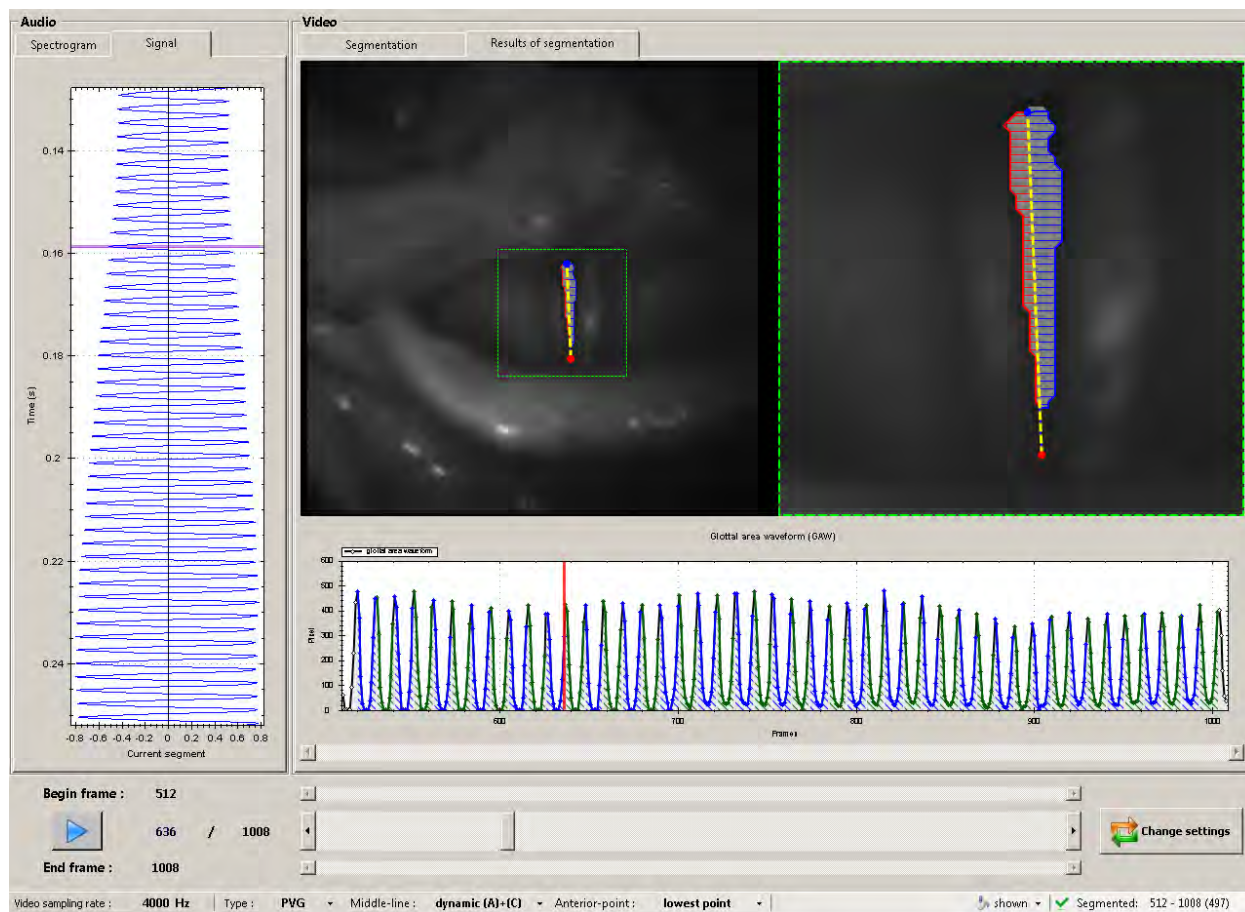
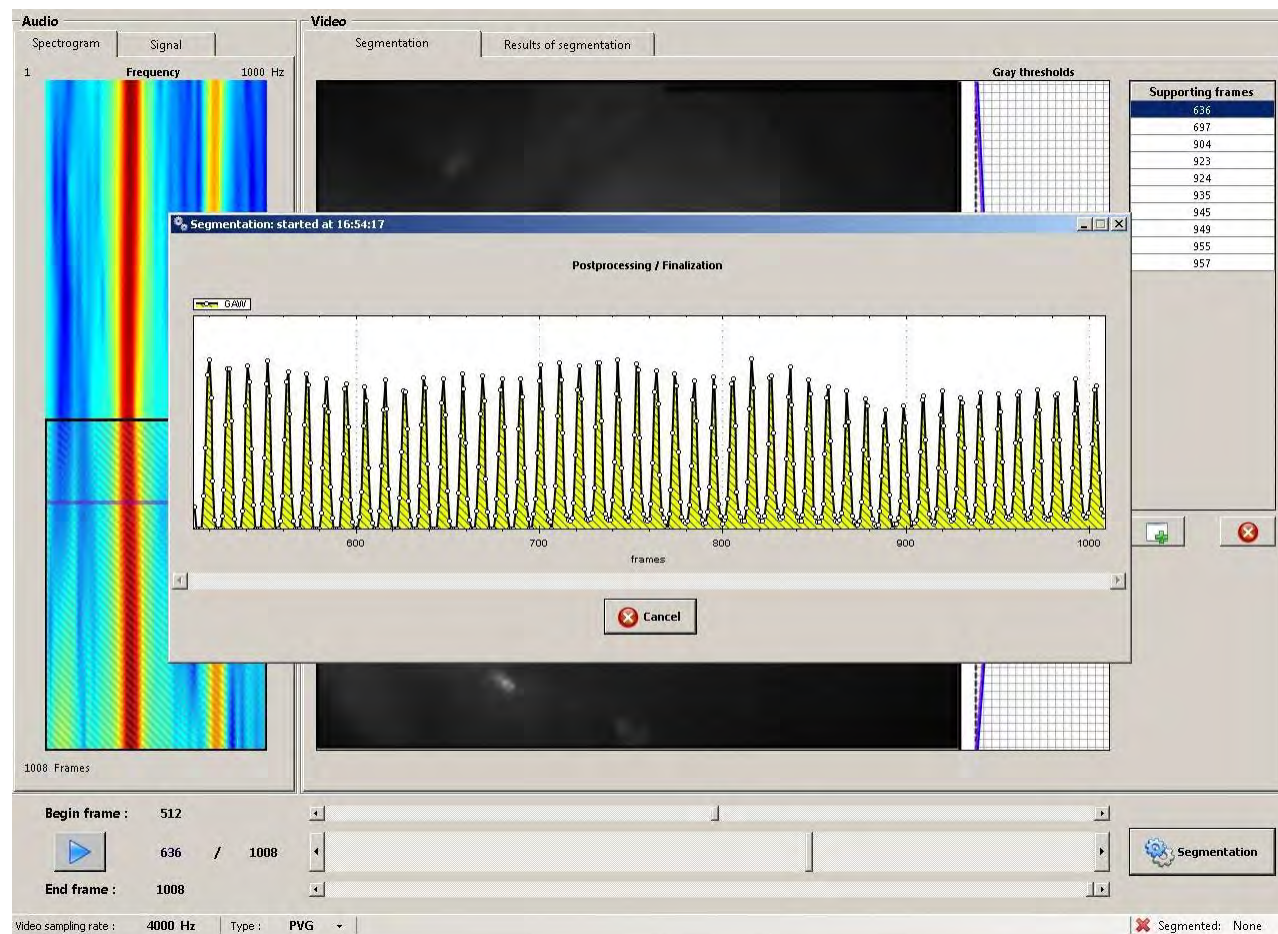# High speed films and phonovibrogram

The results* of the segmentation.
The Glottal
Area Wave form (GAW) are shown with frames on the horizental axis and pixel on the vertical axis
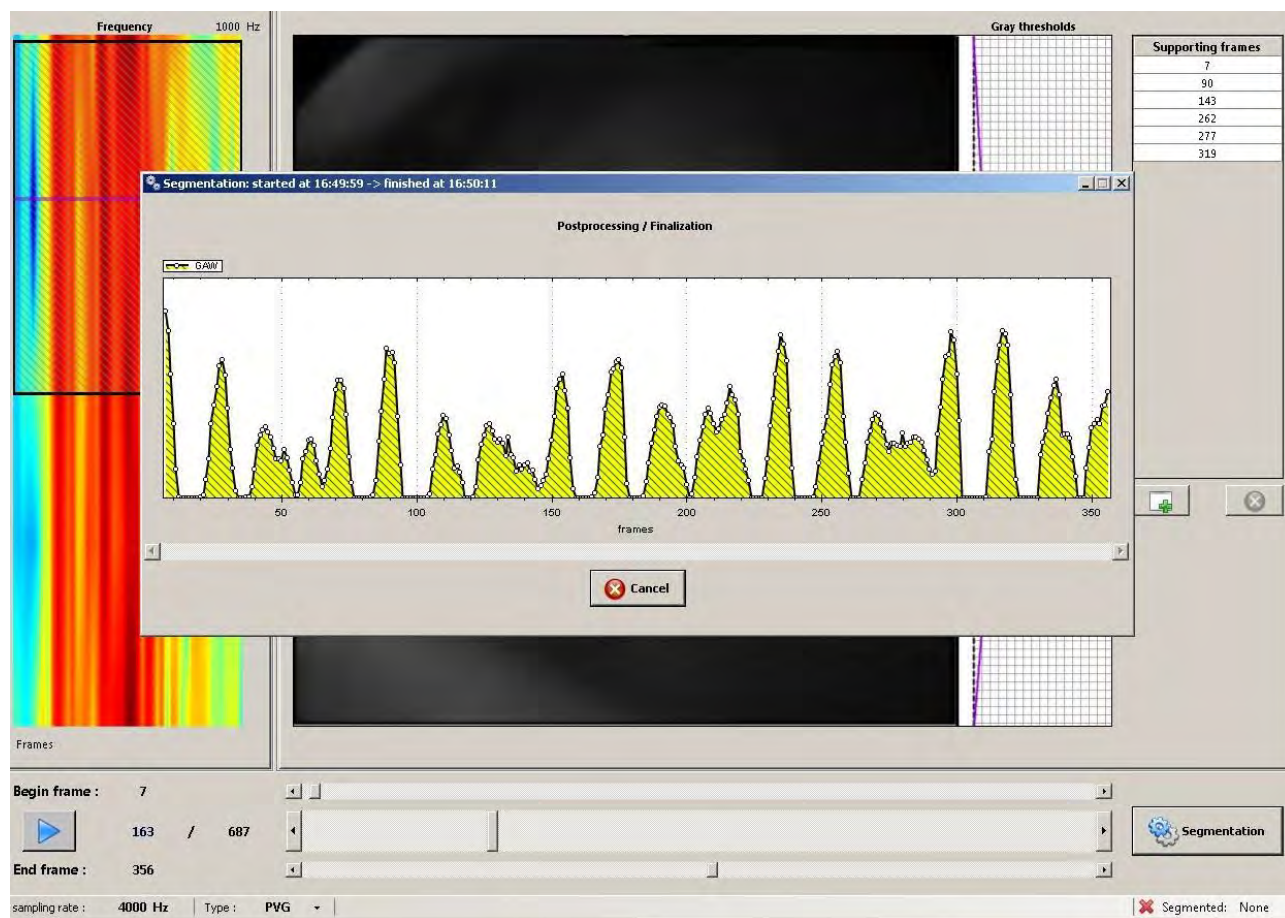
*the contest winning female

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High speed films and phonovibrogram

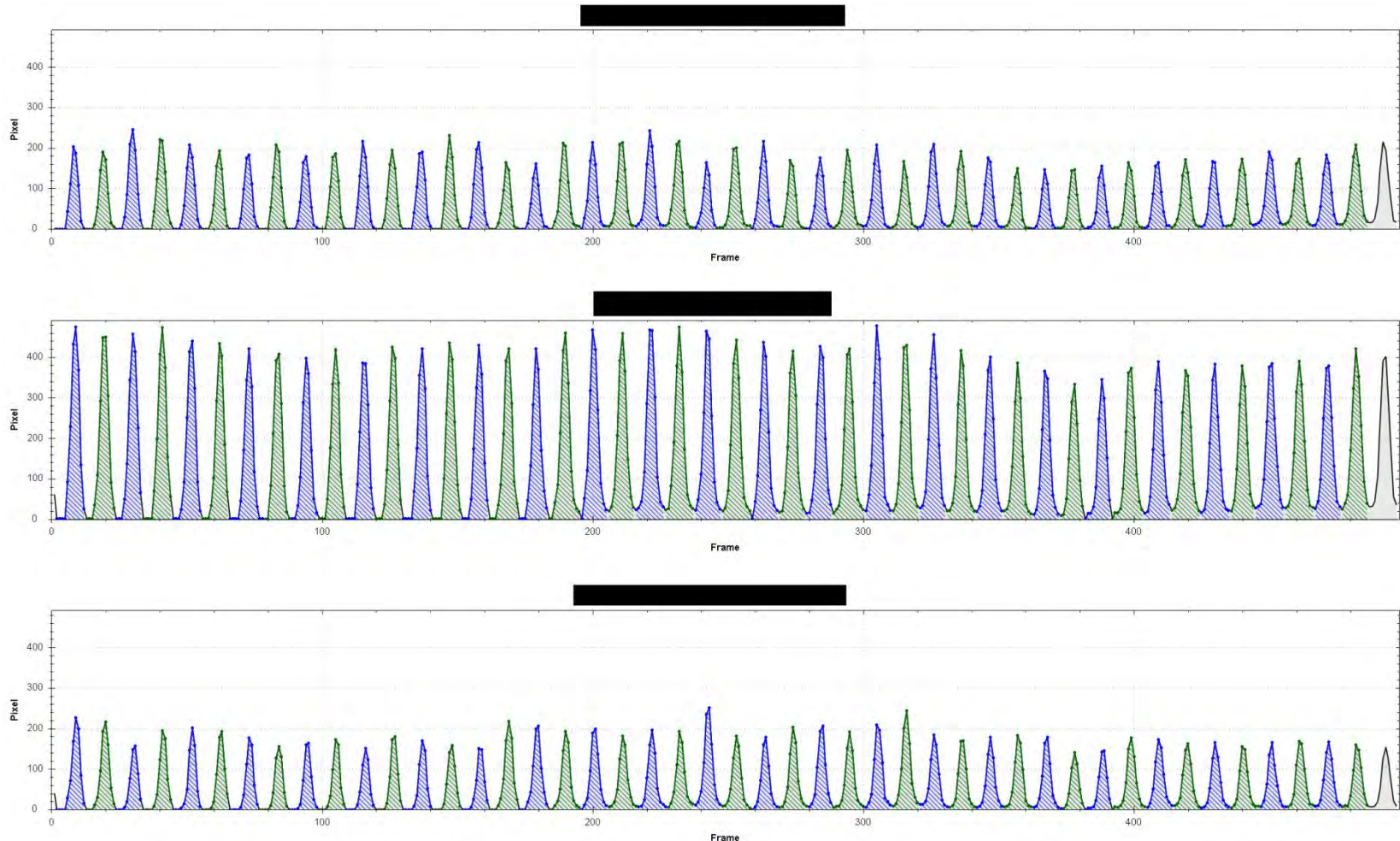The regulation of the single movement presenting the area of the phonovibrogram of a contest winning female

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High speed films and phonovibrogram

Irregularity of the single area measurements are seen of the 59 years old male

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GAW cycles of a contest winning female

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GAW cycles of a 59 years old male with extreme dysphonia

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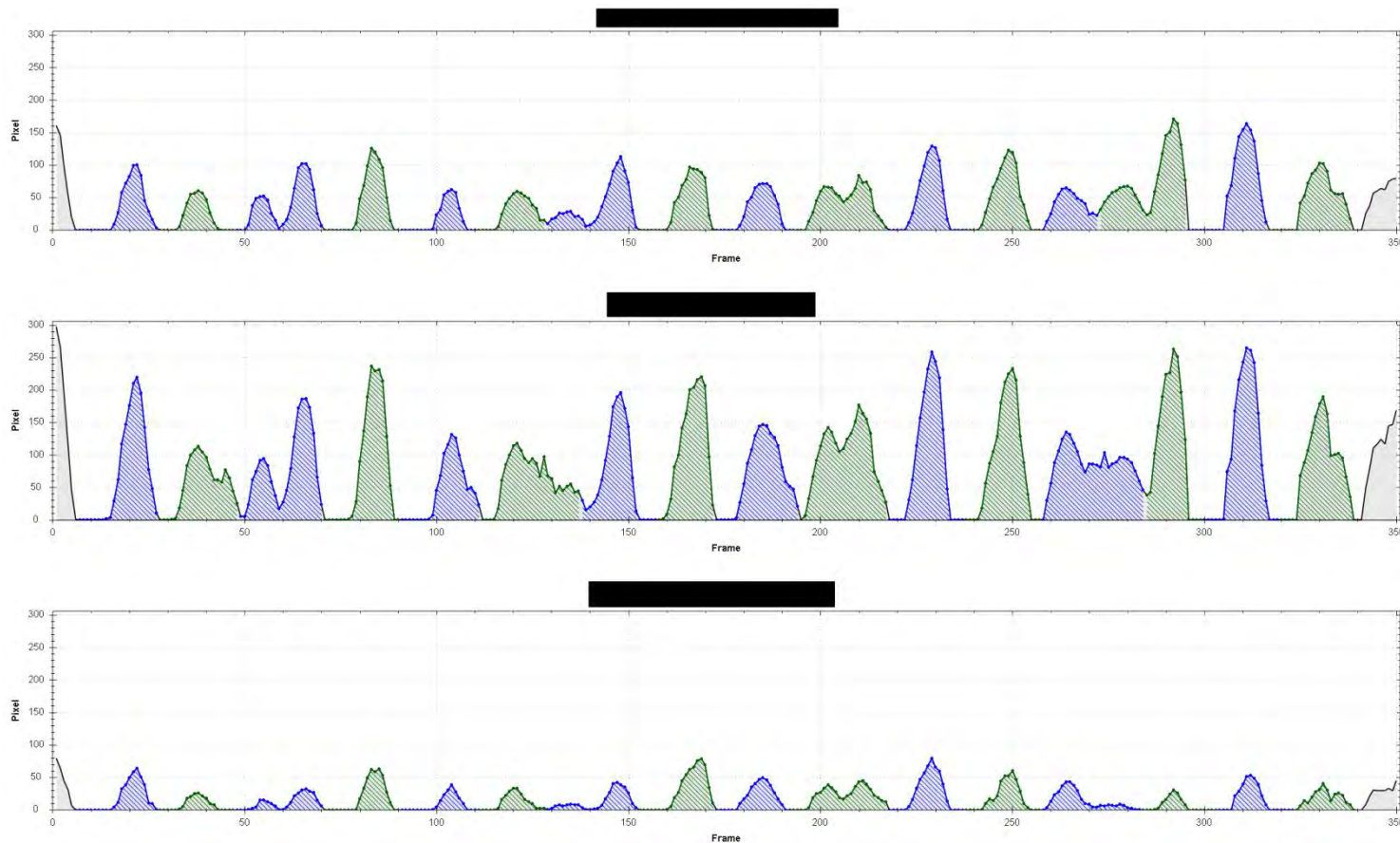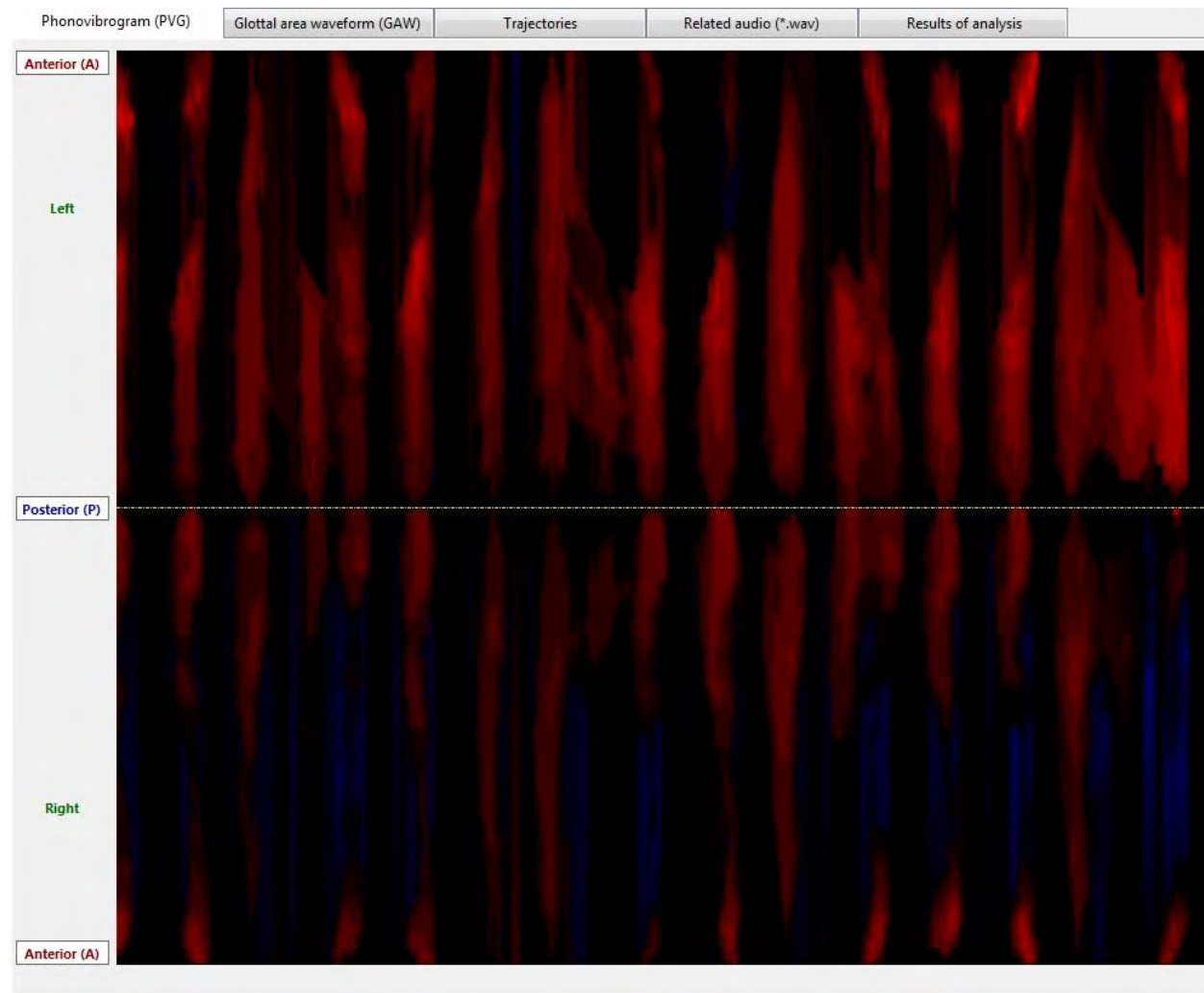
High speed films and phonovibrogram

Phonovibrogram of the contest winning female, showing the regularity of single movement of the right and left vocal folds

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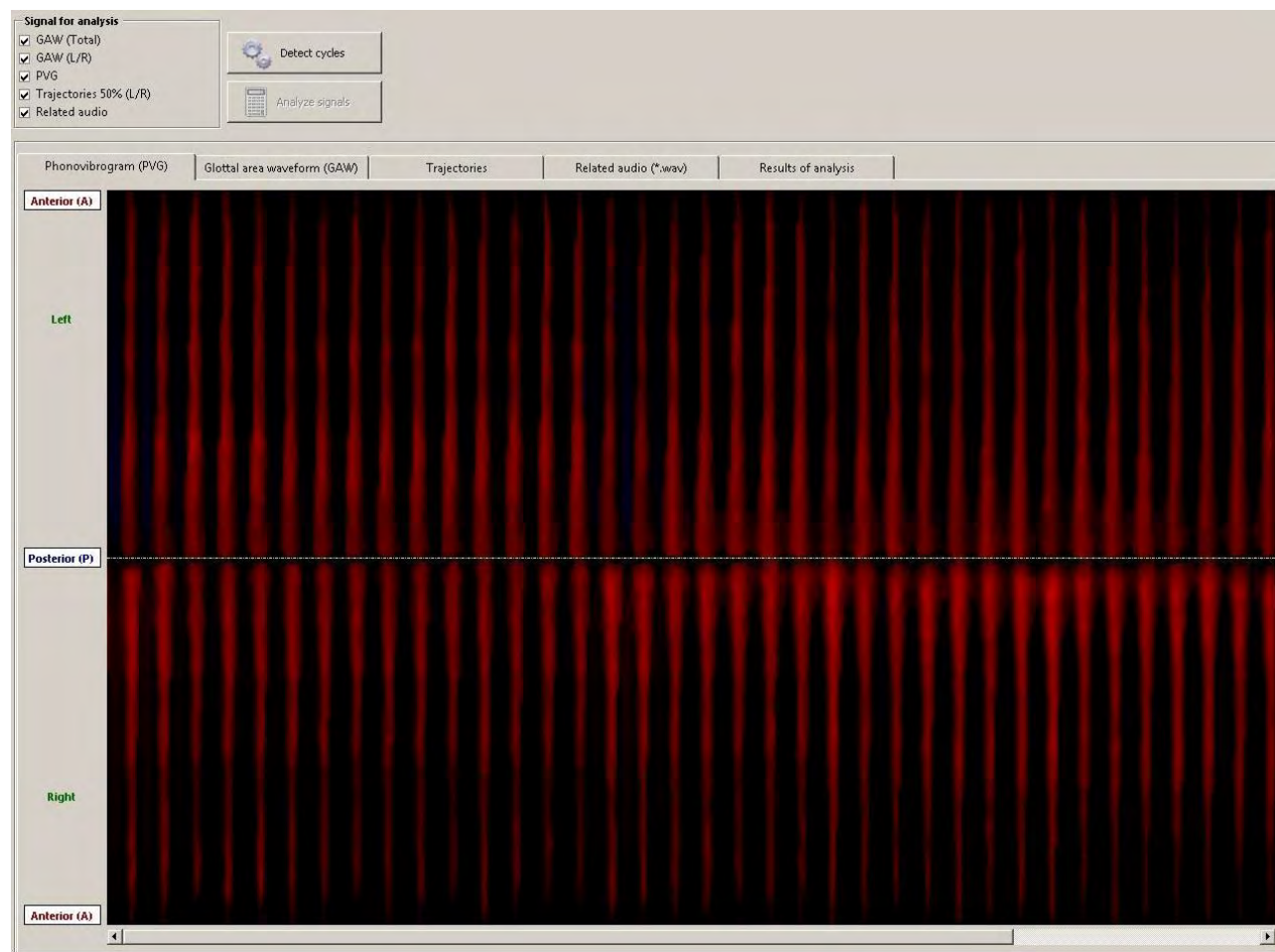
High speed films and phonovibrogram

Phonovibrogram of a 59 years old male with extreme dysphonia do to a heavy acute laryngitis

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Calculated measures for the signals of Glottal Area Waveform and Glottal Trajectories

From a contest winning female

			[MEAN]	[STD]	[MIN]	[MAX]
Stiffness	[GAW]		0,38	0,02	0,333	0,413
Stiffness	[GAW]	[Left]	0,391	0,024	0,338	0,432
Stiffness	[GAW]	[Right]	0,395	0,024	0,352	0,451
Stiffness	[Traj-50%]	[Left]	0,483	0,043	0,371	0,625
Stiffness	[Traj-50%]	[Right]	0,486	0,029	0,392	0,513

From a 59 years old male with extreme dysphonia do to a heavy acute laryngitis

			[MEAN]	[STD]	[MIN]	[MAX]
Stiffness	[GAW]		0,29	0,059	0,207	0,418
Stiffness	[GAW]	[Left]	0,313	0,056	0,232	0,444
Stiffness	[GAW]	[Right]	0,298	0,04	0,215	0,376
Stiffness	[Traj-50%]	[Left]	0,356	0,069	0,251	0,479
Stiffness	[Traj-50%]	[Right]	0,288	0,037	0,248	0,323

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Statistical analysis of stiffness
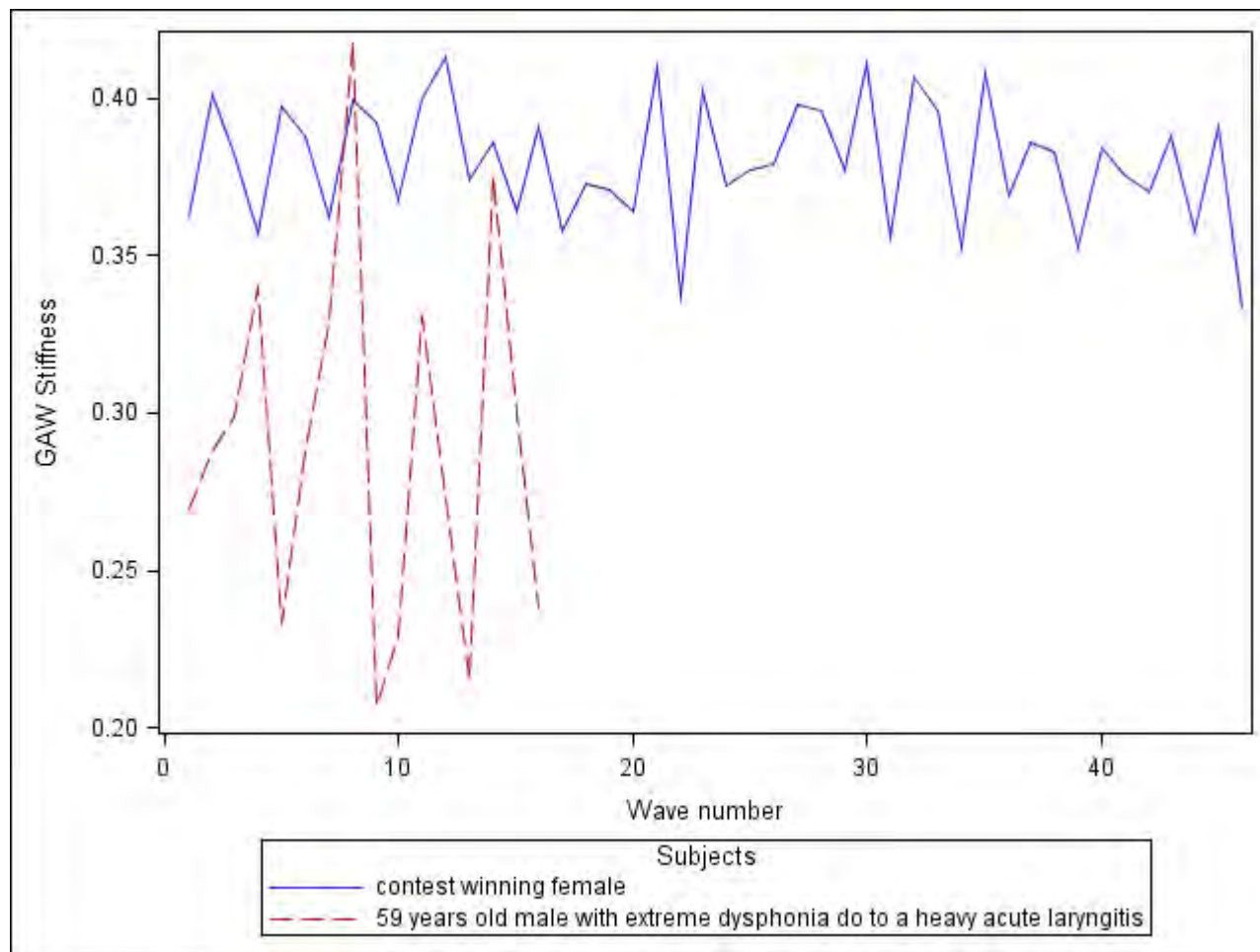
For trained statisticians!!!

- A statistical comparison of stiffness measurements of the two subjects can be done under the assumption that all the measurements on the same subject follow the same Normal distribution. The hypothesis that the variation is the same for the two subjects can be tested in the likelihood ratio test where the -2log likelihood difference is chi-square distributed with 1 degree of freedom when it is assumed that the measurements have different means for the two subjects.

Statistical model	-2 log likelihood	Likelihood ratio test statistic	P-value (chi-square distribution with 1 degree of freedom)
Subjects have different mean and variance	-261.9		
Subjects have different mean and same variance	-228.6	33.30	<0.00001

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Statistical conclusions

For untrained statisticians!!!

- The statistical model shows that there is a statistical significant difference in the variation of the GAW stiffness between the two subjects

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Conclusions

- Till now we have seen a difference between high quality voices and other voices and in this study we will present a quantified measure of the vocal fold stiffness calculated from individual vocal fold cycles as well as average measures.

- It is our impression that the system Glottis Analysis Tools stiffness calculations can be used clinically to differentiate between high and low quality voices.

- In the future, stiffness might be used to determine the treatment effect in voice pathology.

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Find the slides on: http://www.mpedersen.org

Thank you for your attention

References

- Deliyski, D., Hillman, R., 2010. State of the art laryngeal imaging: Research and clinical implications. Curr. Opin. Otolaryngol. Head Neck Surg. 18, 147-152.

- Pedersen, M., Eeg, M., Jønsson, A., 2013. Video stroboscopy and high-speed films of pathological voices. Presented at 4th Symposium of Advanced Voice Assessment, Copenhagen.

- Döllinger, M., Hoppe, U., Hettlich, F., Lohscheller, J., Schubert, S., Eysholdt, U., 2002. Vibration parameter extraction from endoscopic image series of the vocal folds. IEEE Trans. Biomed. Eng. 49, 773-781.

- Lohscheller, J., Eysholdt, U., Toy, H., Döllinger, M., 2008. Phonovibrography: mapping high-speed movies of vocal fold vibrations into 2-d diagrams for vi- sualizing and analyzing the underlying laryngeal dynamics. IEEE Trans. Med. Imaging 27, 300-309.

- Pedersen, M., Eeg, M., Jønsson, A., Mahmood, S., 2015. Chapter 8. Working with Wolf Ltd. HRES Endocam 5562 analytic system for high-speed recordings. *In press*

- *Evt. "Can phonovibrograms be used in clinical voice pathology". In press*

- *Evt. "Technology advances in diagnostics of vocal folds function". In press*

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