



Grenoble July 19th 2023

Review of Mr Hugo LEHOUX Doctoral Thesis entitled « *Biomechanics and acoustics of voice production [Biomechanika a akustika tvorby hlasu]* »
Palacký University in Olomouc, Czech Republic

This doctoral thesis investigates vocal-fold vibratory patterns *ex vivo* on a specially-designed testbed, *in vivo* on a female singer, and *in silico* on simulating vocal-fold vibratory images.

The manuscript is composed of two abstracts (one in english, one in Czech), a well-written introduction and state-of-the-art part of 30 pages covering all aspects required to understand the work, and a 12-pages synthetic description of the core of the thesis, the motivations and contributions of the doctoral student. Four published papers are provided as supplementary chapters. These peer-reviewed papers have been published in renowned journals of the field (*Journal of Voice*, *Journal of Sound and Vibration*, *Journal of Speech Language and Hearing Research*) and in *Scientific Reports* from Nature publishing group. Mr. Lehoux is first author in three of them.

This thesis is of an excellent standard and presents results that are both remarkable and important for the study of human vocal production. Among the major advances brought by this highly original work, we can note :

- an innovative method for reproducing the anechoic termination of human lungs on a test bench
- the demonstration that laryngeal-vibrator frequency jumps are not necessarily related to the resonance properties of the subglottal tract
- the proof that chest and head registers can occur throughout the whole singer's vocal range and not only on a limited overlapping frequency range

These very interesting results raise a number of questions and comments.

Questions :

- An important aspect is the VF mechanical resonances. Unfortunately, they were not measured in *ex vivo* studies. Could the lowering of f_0 in subglottally resonant conditions of study I be related to mechanical properties of VF tissues ?
- Subglottal flow was kept constant at 400 mL.s⁻¹ in study I. Was it chosen on purpose ? Have you thought of exploring other ranges ?
- In study II, 3 out of 5 larynges did not exhibit frequency jumps, whatever the subglottal condition. Do you have any explanation for this result ? Could it be related to the age of the donator ? Have you explored higher airflow range ?

GIPSA-lab

11 rue des Mathématiques - Domaine universitaire - BP 46
38402 Saint Martin d'Hères Cedex France
Tél +33 (0)4.76.57.45.36 – Fax +33 (0)4.76.57.47.10
Nathalie.Henrich@gipsa-lab.grenoble-inp.fr
<http://www.gipsa-lab.inpg.fr/~nathalie.henrich>



- In study III, the singer alternates between chest and head registers. Do you know on which basis she qualifies her phonation of chest or head : i.e. acoustics, proprioceptive feelings, ... ? Does she practice mixed voice as well ?
- As only NAQ_{GA} and $CgQkym$ were found to consistently vary between chest-like and head-like sounds in Study III, you suggested that glottal closing speed would be the most relevant parameter. Why isn't this also reflected in speed quotient (SQkym) ?
- The parameters derived from kymograms depend on the selected line. How was it handled in the analysis ?

Minor comments :

p.6 : the resonance frequency and bandwidth of an acoustical cavity depend indeed on the geometry but not only. They vary also with boundary conditions at tract inlet and outlet, and with wall damping properties.

p.17 : About control of f_0 , a paper to mention is « Titze, I. R. (2011). Vocal Fold Mass Is Not A Useful Quantity for Describing F_0 in Vocalization. Journal of Speech, Language, and Hearing Research, 54(2), 520-522. »

p. 22 : « it is generally recognized that there are four **laryngeal** registers ».

Be cautious that the notion of laryngeal mechanism is not synonymous of register in the broadest sense. It would be more accurate to describe them separately. For instance, chest voice is always produced in M1, but head voice may be produced in M1 or M2 for male singers. It would be nice to present the notion of mixed voice here, as it can be useful for understanding the sound confusion in study III.

The laryngeal mechanisms are not defined on the basis of distinct vibratory regimes of the VFs, but on the coupling or dissociation within the VF layered microstructure.

p. 31 « The study » -> To study

p.46 (and when cited) : « Henrich Bernardoni » -> « Henrich » for all references before 2014

In conclusion, this dissertation fulfills all the requirements imposed on a Ph.D. thesis. It has a very high scientific level. Mr Hugo Lehoux demonstrated his scientific expertise and his great ability to publish the results of his studies in high-level journals. Therefore, I strongly recommend his thesis for the defense.

Nathalie Henrich Bernardoni

CNRS Research Director in Voice Sciences

GIPSA-lab

11 rue des Mathématiques - Domaine universitaire - BP 46

38402 Saint Martin d'Hères Cedex France

Tél +33 (0)4.76.57.45.36 – Fax +33 (0)4.76.57.47.10

Nathalie.Henrich@gipsa-lab.grenoble-inp.fr

<http://www.gipsa-lab.inpg.fr/~nathalie.henrich>