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Robin Tournemenne, Jean-François Petiot, Joel Gilbert. INHARMONICITY OF A TRUMPET WITH A VARIABLE DEPTH MOUTHPIECE. Vienna Talk 2015 on Music Acoustics, Sep 2015, Vienna, Austria. hal-02587854

HAL Id: hal-02587854

<https://hal.science/hal-02587854v1>

Submitted on 15 May 2020

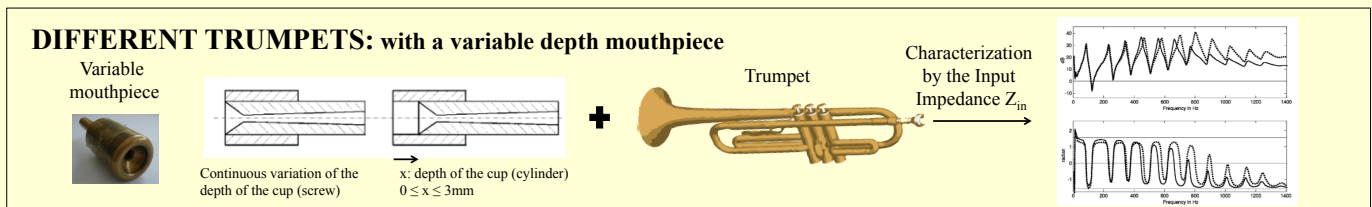
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INHARMONICITY OF A TRUMPET WITH A VARIABLE DEPTH MOUTHPIECE

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3 INVESTIGATION METHODS

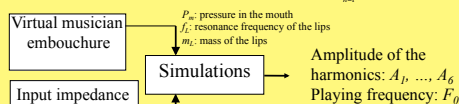
Resonance frequencies of the INPUT IMPEDANCE

- Measurement of the input impedance Z_{in} for one given depth ($x=0$).
- Extrapolation of the input impedance for different depths by impedance calculation (addition of a cylinder of length x with the transmission line formalism)
- Extraction of the resonances frequencies of the impedance, for different mouthpiece depths

Playing frequencies of SIMULATED SOUNDS

- Simulation in the frequency domain with the harmonic balance technique:

$$p(t) = \sum_{n=1}^N A_n \cos(2\pi j_n F_n t + \phi_n)$$



- 4 Fingerings: D₀ D₁ D₂ D₂₃
- 5 Regimes: R2 to R6
- 30 Mouthpiece positions (discretization of x)
- 300 virtual "embouchures"

Playing frequency of a note averaged on the different embouchures

Playing frequencies of RECORDED SOUNDS

- Trumpet with the variable mouthpiece played by a musician
- Extraction of the playing frequencies of the sounds

- 4 Fingerings: D₀ D₁ D₂ D₂₃
- 5 Regimes: R2 to R6
- 3 Mouthpiece positions: $x=0\text{mm}$, 1.5mm and 3mm
- 3 repetitions

Playing frequency of a note averaged on the 3 repetitions

OBJECTIVE

Study of the agreement between the playing frequencies of the recorded sounds, the playing frequencies of the simulated sounds, the resonance frequencies of the impedance

⇒ Toward a prediction of the intonation

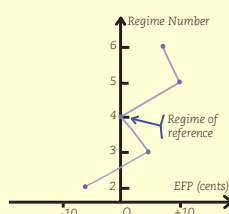
ESTIMATION OF THE INHARMONICITY: The Equivalent Fundamental Pitch (EFP)

- Choice of a reference $f(ref)$: 4th regime of the fingering D₀ (tuning note)
- EFP of each note (cent):

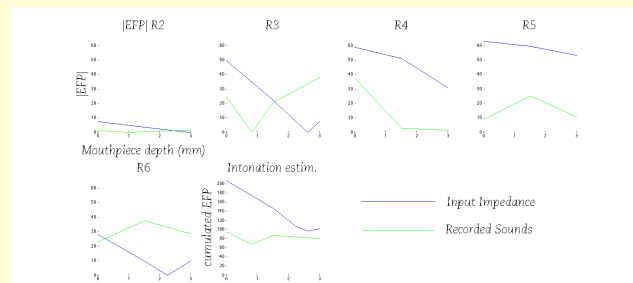
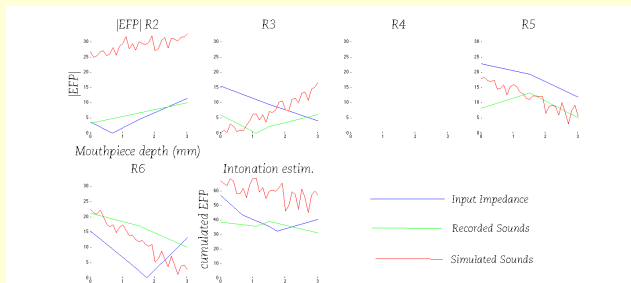
$$EFP(i) = 1200 \log_2 \left(\frac{f(i)/i}{f(ref)/ref} \right)$$

- Proposition of an estimator of the global intonation for the whole trumpet

$$Intonation_{estim} = \sum_{j \in \{fingerings\}} \sum_{i \in \{regimes\}} |EFP_{ij}|$$



RESULTS



Evolution of the EFPs and the Intonation according to the mouthpiece depth x for different regimes (R2 to R6), for fingering D₀ only (left) and fingerings D₀, D₁, D₂, D₂₃ (right)

CONCLUSIONS

- For Fingering D₀: noticeable similarities in the global behaviour for the 3 methods:
 - The general evolution trends of the EFPs for the different regimes are consistent (except for regime 3 for the impedance)
 - The absolute values of the EFPs are consistent (except for regime 2 and the simulations)
 - Influence of the virtual embouchure on the simulated sounds. Necessity of a method to select the embouchures
- For all the fingerings
 - The precision of the intonation predictions remains low with the impedance. Results in progress for the simulations...