INHARMONICITY OF A TRUMPET WITH A VARIABLE DEPTH MOUTHPIECE

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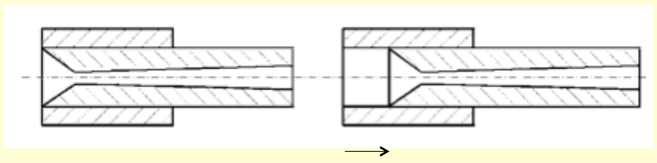
DIFFERENT TRUMPETS: with a variable depth mouthpiece

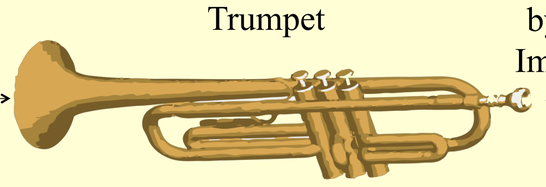
Variable mouthpiece



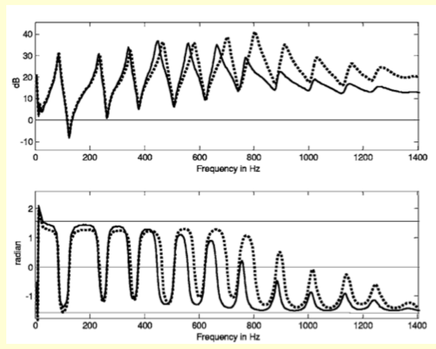
Continuous variation of the depth of the cup (screw)

x: depth of the cup (cylinder)
$0 \leq x \leq 3$mm

Trumpet



Characterization by the Input Impedance Z_{in}



3 INVESTIGATION METHODS:

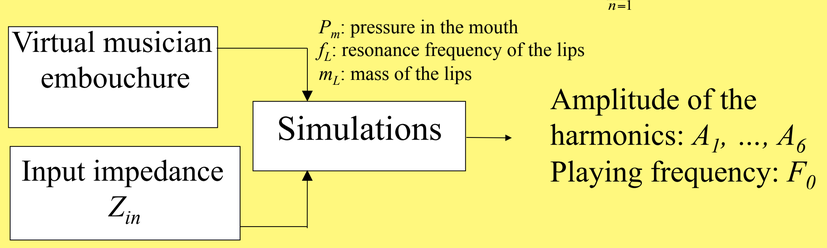
Resonance frequencies of the INPUT IMPEDANCE

- 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:

$$p(t) = C_o + \sum_{n=1}^{N} A_n.\cos(2\pi jnF_o t + \varphi_n)$$



- 4 Fingerings: D_0 D_1 D_2 D_{23}
- 5 Regimes: r2 to r6
- 30 Mouthpiece positions:
- 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: D_0 D_1 D_2 D_{23}
- 5 Regimes: r2 to r6
- 3 Mouthpiece positions: 0mm, 1.5mm and 3mm
- 3 repetitions

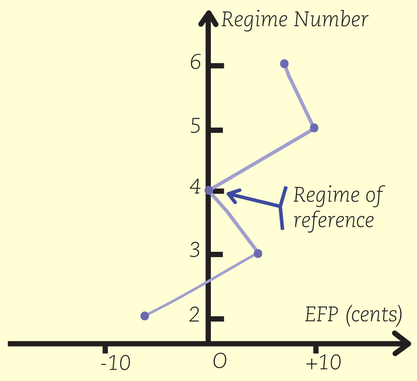
Playing frequency of a note averaged on the 3 repetitions

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

=> Prediction of the intonation

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



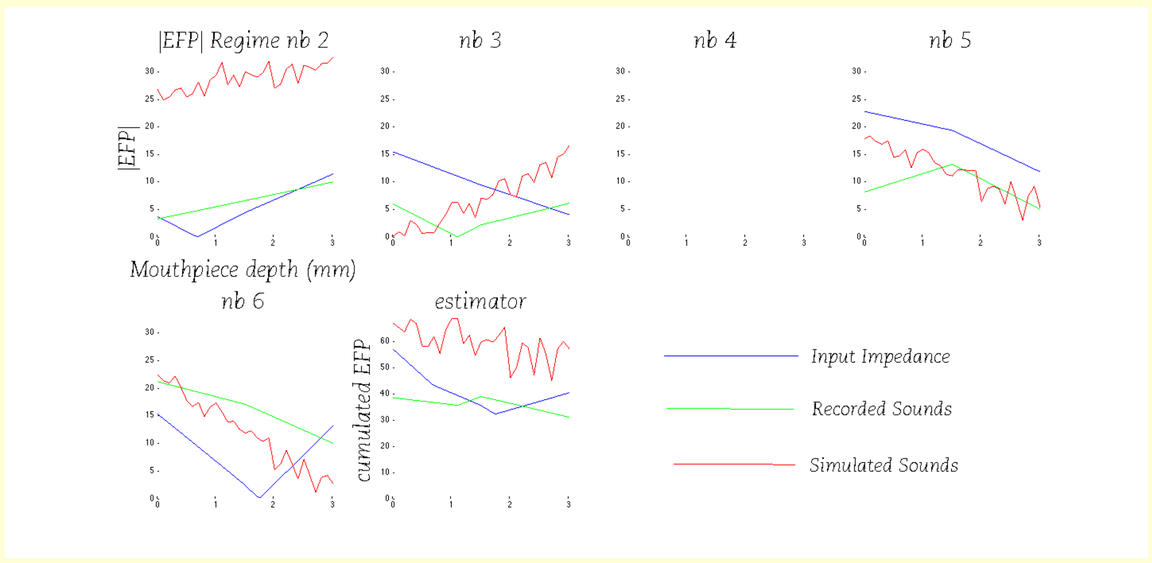
- Choice of a reference *f(ref)*: 4th regime of the fingering D_0 (tuning note)
- EFP of each note (cent):

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

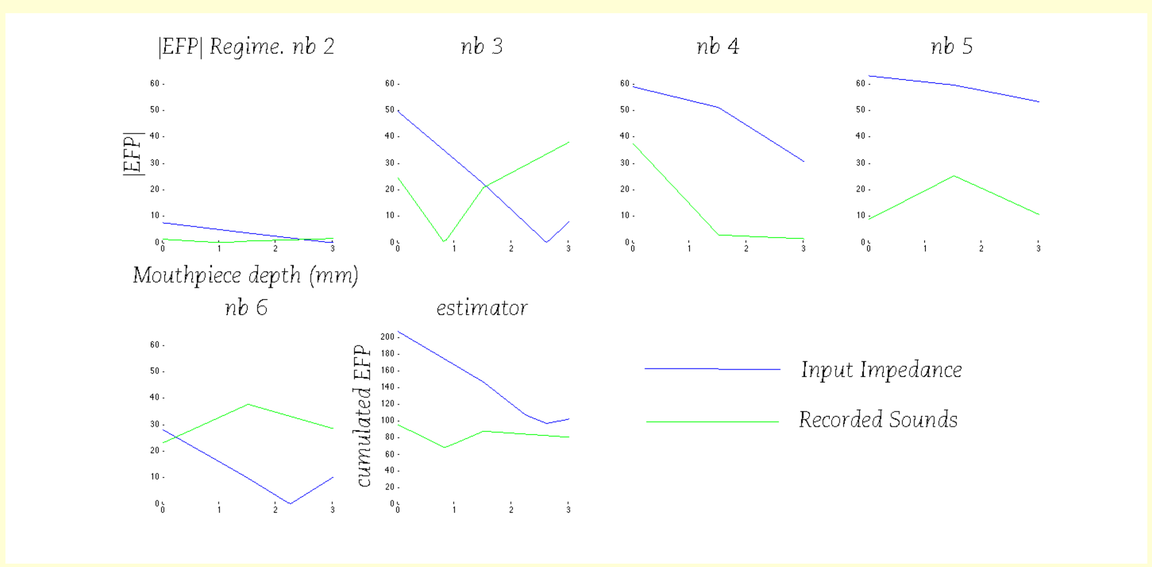
- Proposition of a estimator of the global intonation of the whole trumpet

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

RESULTS:



Evolution of the EFPs according to the mouthpiece depth x (fingering D_0)



Evolution of the EFPs according to the mouthpiece depth x (fingerings D_0, D_1, D_2, D_{23})

CONCLUDING REMARKS

- For Fingering D_0: 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
- For all the fingerings
  - The precision of the intonation predictions remains low: not reasonable to make accurate predictions of the intonation from the impedance. Results in progress for the simulations…

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