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INHARMONICITY OF A TRUMPET WITH A VARIABLE DEPTH MOUTHPIECE

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DIFFERENT TRUMPETS: with a variable depth mouthpiece

3 INVESTIGATION METHODS

Resonance frequencies of the INPUT IMPEDANCE
- Measurement of the input impedance Zᵢ 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:

\[ p(t) = \sum A_n \cos(2\pi f_n t + \phi_n) \]

Virtual musician embouchure
Input impedance \( Z_{in} \)
Simulations

Playing frequencies of RECORDED SOUNDS
- Trumpet with the variable mouthpiece played by a musician
- Extraction of the playing frequencies of the sounds
- 4 Fingering: D₁, D₂, D₃, D₄
- 5 Regimes: R₂ to R₆
- 3 Mouthpiece positions: x=0mm, 1.5mm and 3mm
- 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 D₂ (tuning note)
- EFP of each note (cent):

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

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

\[ \text{Intonation}_{\text{global}} = \sum_{i \in \{\text{fingering}\}} \sum_{r \in \{\text{regime}\}} |EFP_i| \]

RESULTS

Evolution of the EFPs and the Intonation according to the mouthpiece depth x for different regimes (R₂ to R₆), for fingering D₁ (only left) and fingerings D₄, D₃, D₂, D₁ (right)

CONCLUSIONS

- For Fingering D₂: 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…