Comparison of mouthpiece pressure signal and reed bending signal on clarinet and saxophone

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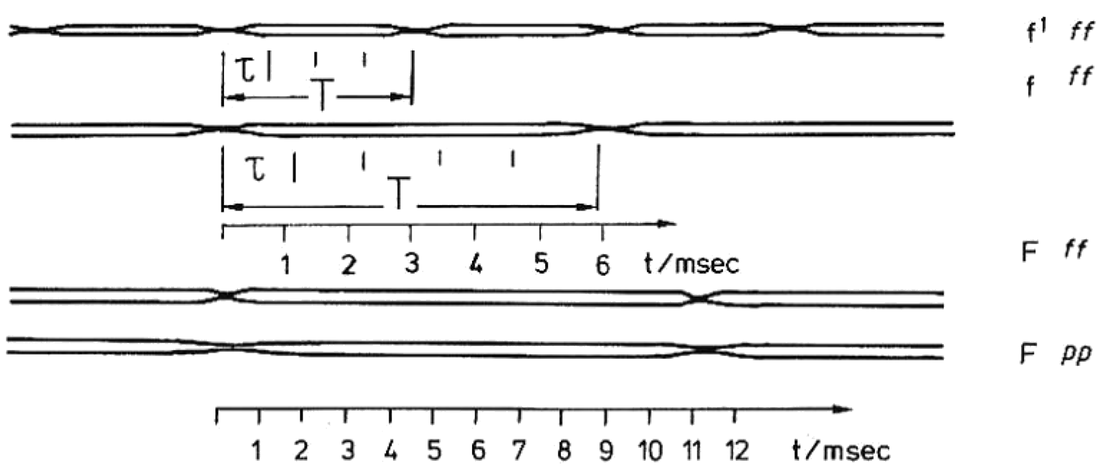
Vienna Talk 2015
on Music Acoustics
"Bridging the Gaps"
16–19 September 2015

Background

The clarinet and the saxophone have a similar sound excitation principle. For both instruments, a single reed is mounted to a beak shaped mouthpiece and becomes excited by the player's blowing. Caused by the different shapes of the resonators, the sound of the cylindrical clarinet contains only the odd numbered harmonics, whereas the sound of the conical saxophone contains all members of the harmonic series.

Measurements on double reed instruments by Fransson (1966-68) and Voigt (1975) showed that the closing time of the double reed was constant across a broad range of pitches played on the instrument. Consequently, only the offset period was modulated. Characteristic frequency gaps in the spectrum (formants) of an instrument's sound were then explained by this specific motion pattern of the oscillator (pulse forming theory, Fricke 1975).



Bassoon double reed opening and closing times at F2, F3 and F4: independent of the pitch the closing time (τ) remains the same (after Voigt 1975, S. 217; Fricke 1989, S. 116; Gadermaier 2013, S. 70)

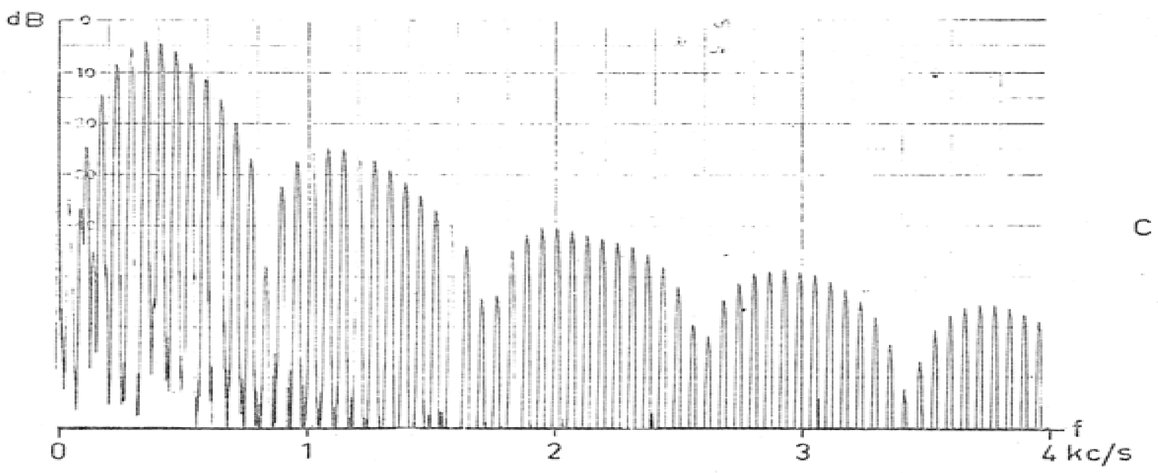


Fig. IV-A-4. (C) Source spectrum produced by ionophone excitation.

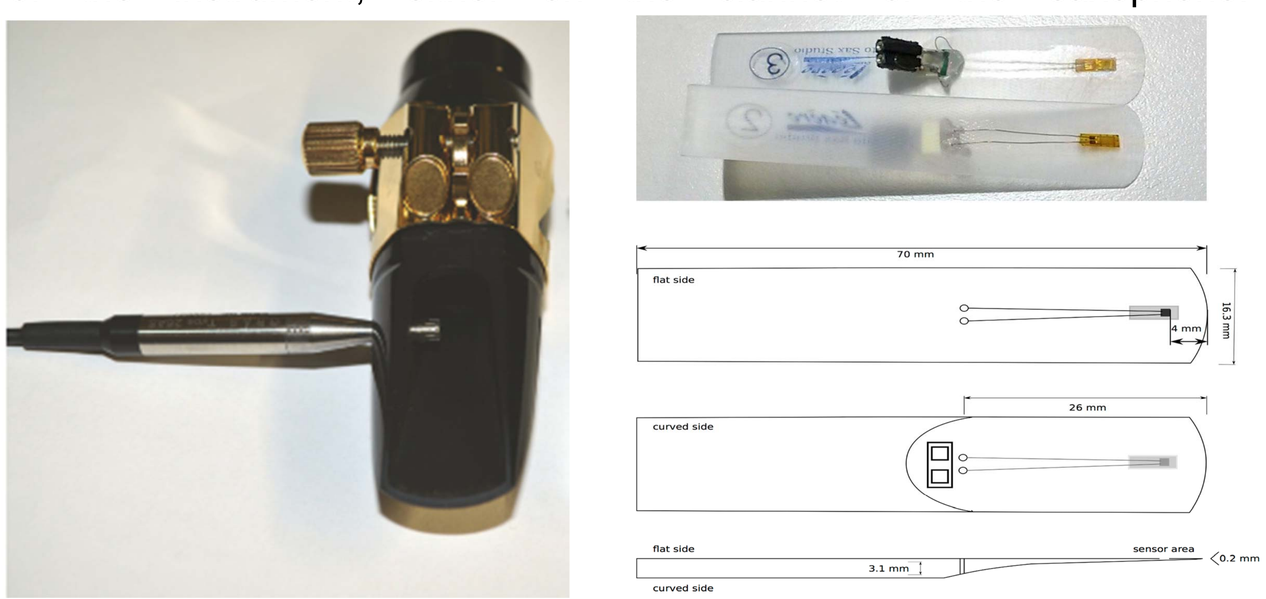
Source spectrum of a typical bassoon timbre, resulting from a oscillating reed with 1.2 ms closing time. (Fransson 1966, S. 36d; Reuter, Oehler 2014, S. 199)

Aims and leading question

Can the pulse forming theory also be applied to single reed instruments like the saxophone and the clarinet?

Methods and Stimuli

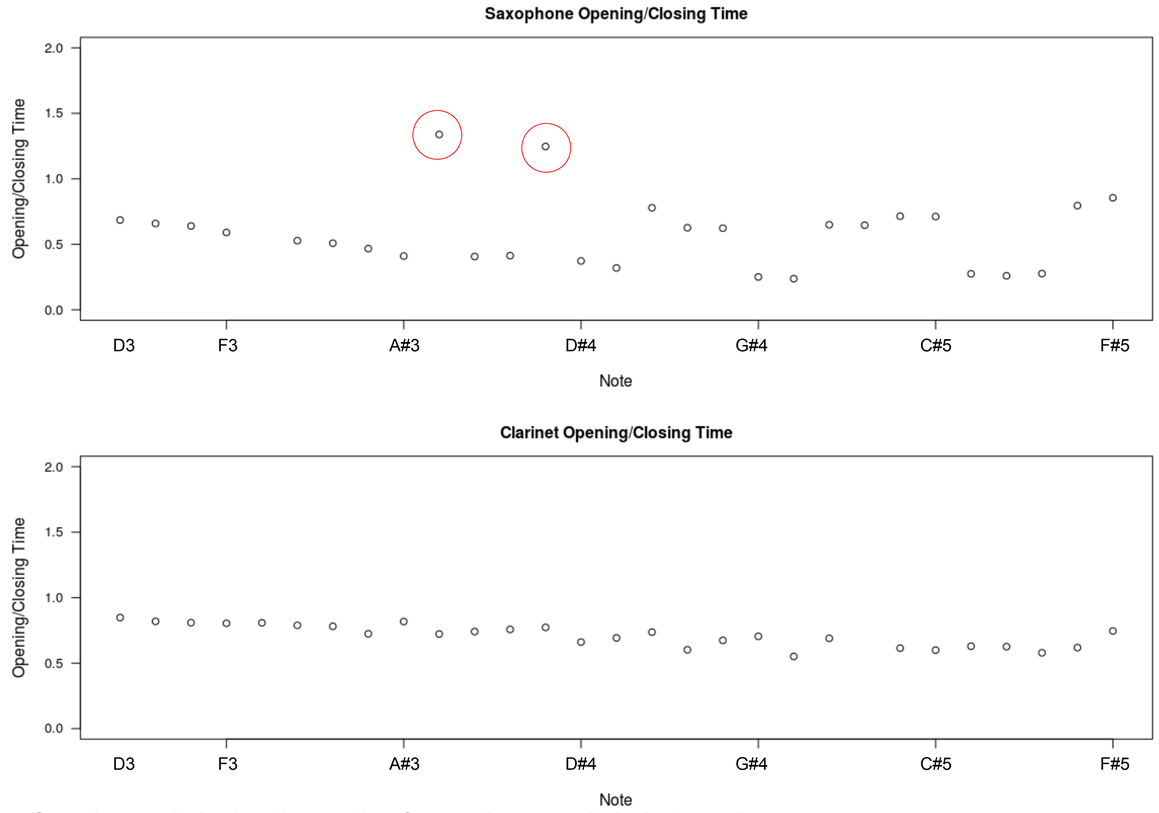
For our measurements on a Bb-clarinet and an alto-saxophone, synthetic single-reeds were equipped with strain gauge sensors, to capture the bending of the reed during sound production (Hofmann, 2015). A pressure transducer (Endevco 8507C-2) inserted into the chamber of the mouthpiece tracked the inner mouthpiece pressure. Two professional players performed a chromatic scale over the whole range of the instrument, either on the clarinet or the saxophone.



Left: Mouthpiece with piezo-resistive pressure transducer. Right: Synthetic single reed with strain gauge sensor.

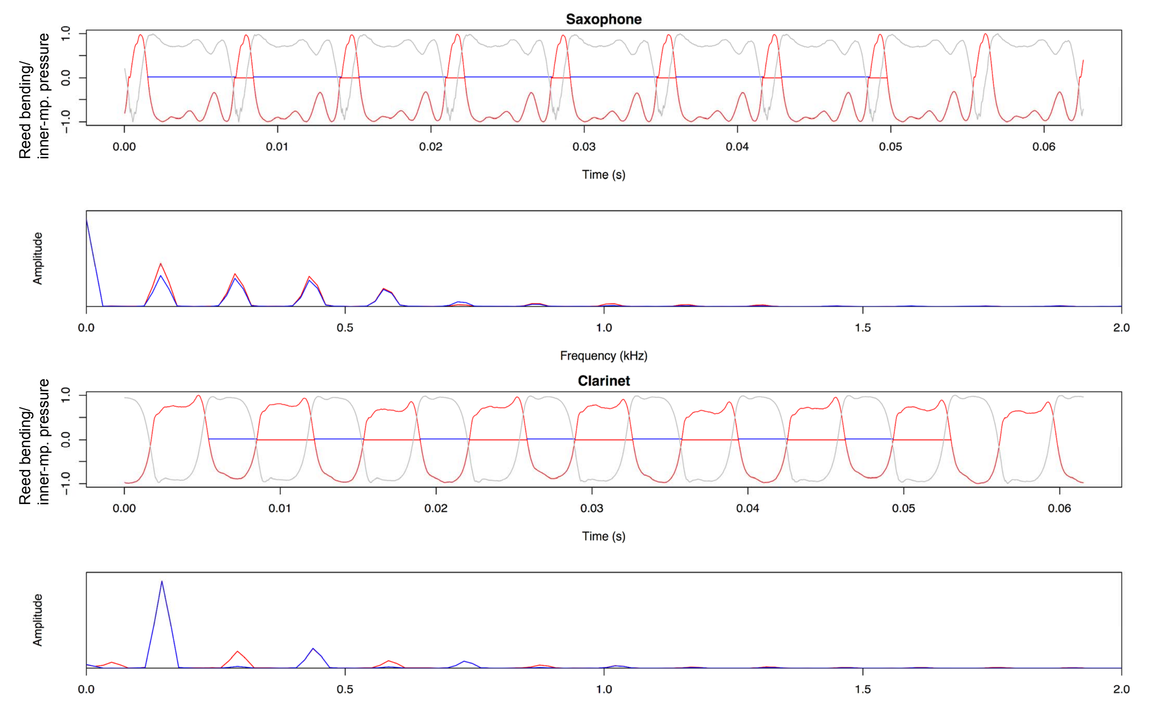
Results

From the reed bending measurements, we calculated the ratio between the opening time and the closing time for each played tone. On the clarinet, this ratio was almost constant for all played tones (M = 0.71, SD = 0.09), whereas on the saxophone these ratios showed larger deviations, but no clear pattern in relation to the played pitch (M = 0.64, SD = 0.44). Closing times for the tones B3 and D4 on the saxophone were shorter than for the neighboring pitches.



Opening and closing time ratio of saxophone and clarinet reeds.

Spectrograms of the reed signal and the mouthpiece pressure signal were calculated for the steady state part of the tones, using a FFT. For the saxophone, the spectrograms for the reed signal and the mouthpiece pressure were almost identical, depicting all members of the harmonic series in a decreasing fashion. Against our expectations, we observed that in the reed signal of the clarinet, also all harmonics were present, whereas only in the mouthpiece pressure signal merely the odd harmonics appeared.



Waveforms (top) and Spectrum (below) for a the tone D3, played on saxophone and clarinet. Reed bending (red) and inner-mouthpiece pressure (grey/blue).

Conclusion

However, these reed bending measurements indicate that the impulse forming theory, which is valid for double reed instruments, can not be transferred to single reed instruments like the clarinet or the saxophone, where the closing times change with the played frequency.

Literature

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Acknowledgements:
The first author was supported by the Austrian Science Fund (FWF) grants: P23248 and 24546.