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A new method for high-speed line-scanning of brass players' vibrating lips using the examples of subcontra G-flat (tuba) and split tones (trombone)

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Abstract

This study aims to develop a device for observation of lip vibrations in brass musicians. To avoid motion artefacts, mouthpieces with probe holes for the endoscope were used. A standardised device with fixed coupling between endoscope and camera on the one hand and mouthpiece with instrument on the other hand was constructed.

For localisation of the probe hole the endoscope was positioned opposite to the mouthpiece so that the outer rim of the mouthpiece was completely visible through the endoscope. The distance between endoscope tip and outer rim was measured and mirrored on a horizontal axis alongside the outer rim. The optimal position for the probe hole resulted and allowed a frontal view on the lips. Thus, lip vibrations were observed with a kymography camera in real-time.

Two examples of high-speed line-scanning illustrate this technique:

While playing a subcontra G-flat (approx. 23 Hz), each lip vibration correlates with a video frame (frame rate 25 Hz). Single sinusoidal lip vibrations can be distinguished.

Split tones (e.g. "Keren" by Iannis Xenakis) are multiphonic effects on brass instruments. Two pitches with different frequencies are played. The pitches alternate so quickly that the human ear notices them simultaneously. Imaging methods like high-speed line-scanning can be used as biofeedback in order to bring these brass playing techniques to perfection.

Keywords: lip vibrations – brass players – kymography – subcontra G-flat – split tones

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1 Introduction

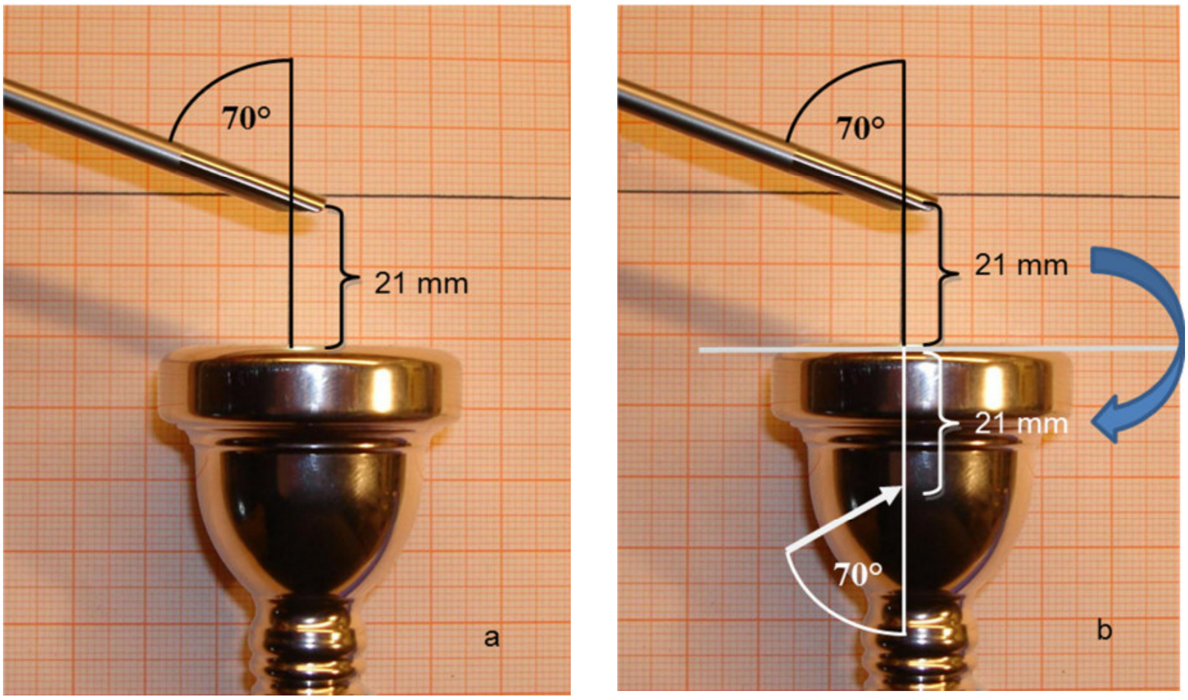
In brass players the strain of daily exercises may result in functional neurological movement disorders (e.g. embouchure dystonia) and/or in morphological lip lesions (e.g. swellings, ruptures of muscle fibres, cicatrices), both of which have a negative impact on the vibrational behaviour of the lips. The examination of lip vibrations is therefore of great relevance in regard to occupational disability.

Lip vibrations of brass players have previously been visualised using different settings and mouthpieces:
With transparent mouthpieces, lip vibrations can be observed stroboscopically (e.g.[1]-[5]), kymographically [6] and by using high-speed techniques (e.g.[7],[8]). The camera is guided free-hand, not connected to the mouthpiece or the instrument. As a result, even slightest movements of the player lead to motion artefacts and require an adjustment of the camera [5].
By using mouthpieces with probe holes for the endoscope, motion artefacts and air leaks (which occur when playing with a visualizer) can be avoided. Such mouthpieces were described by Copley and Strong [9], as well as by Bertsch [10],[11].

The present study aims to develop a device for standardised observation of lip vibrations in different brass instruments (trumpet, trombone, French horn and tuba), with fixed coupling between endoscope and camera on the one hand, and mouthpiece with instrument on the other hand.

2 Methods

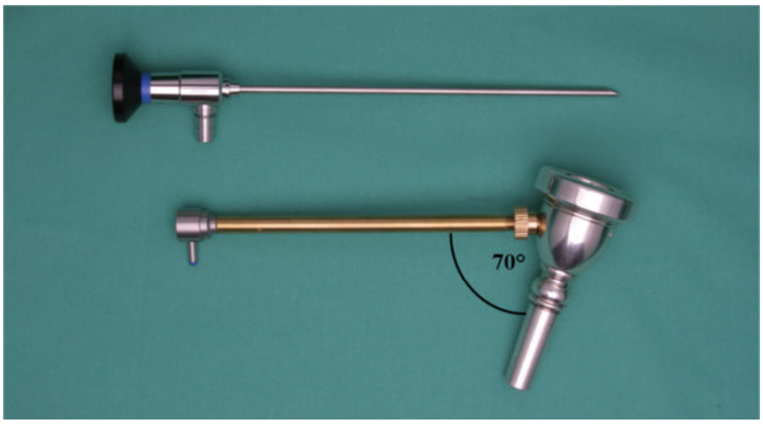
Due to different configurations of the mouthpieces (size, shape etc.), the position of the probe hole had to be determined separately for each individual mouthpiece. This was done by positioning the 70° endoscope above the cup of the mouthpiece so that the outer rim of the mouthpiece was completely visible through the endoscope (cf. fig. 1a). The distance between endoscope tip and outer rim was measured and mirrored on a horizontal axis along the outer rim (cf. fig. 1b: 21 mm).



Source: (Mauersberger, 2016, [12])

Figure 1: determining the position of the probe hole in a trombone mouthpiece:
a) measurement of the distance between endoscope tip and outer rim of the mouthpiece
b) mirrored distance for positioning of the probe hole

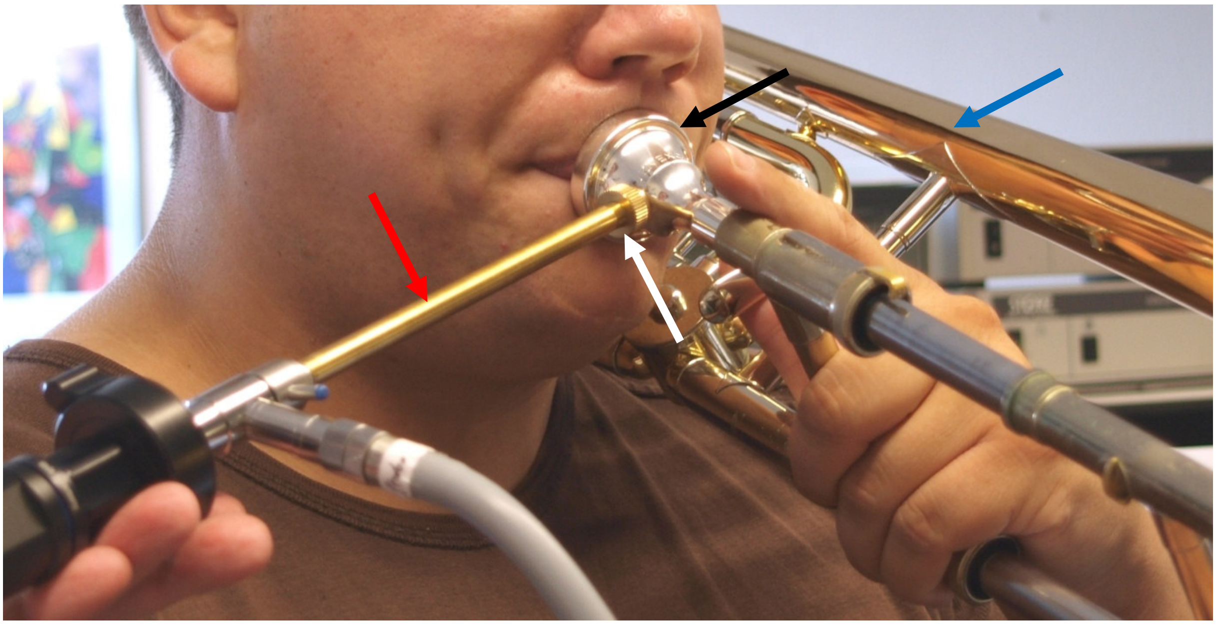
This measurement defined the optimal position for the probe hole. The probe hole was drilled at a 70° angle into the cup of the mouthpiece (cf. white arrow in fig. 1b), and a thread was tapped into it. A guiding sleeve with a knurled screw was subsequently screwed into the hole (cf. fig. 2, lower image).



Source: (Mauersberger, 2016, [12])

Figure 2: tuba mouthpiece with fixed guiding sleeve and separate endoscope

The 70° endoscope (cf. fig. 2, upper image) was inserted into the guiding sleeve and fixed with a coupler. Fine adjustments could be made by turning the knurled screw of the guiding sleeve slightly upwards or downwards, depending on the configuration of the mouthpiece (semi-spherical or conical). Lighting was provided by a fibre optic cable, screwed onto the endoscope.



Source: (Mauersberger, 2016, [12])

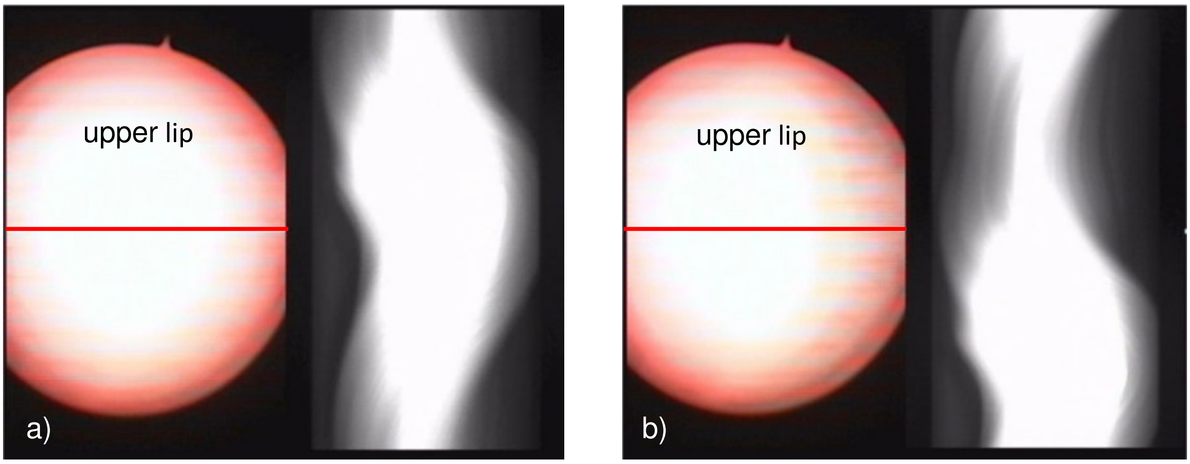
Figure 3: close-up view of a 25-year-old trombonist; red arrow: guiding sleeve, white arrow: knurled screw, black arrow: mouthpiece, blue arrow: trombone

The mouthpiece was connected to the instrument, and the kymography camera was clipped onto the endoscope. The proband was able to blow into the mouthpiece under familiar playing conditions (cf. fig. 3). Thus, lip vibrations were observed with a kymography camera in real-time.

3 Results

Two examples of high-speed line-scanning [12] illustrate this technique:

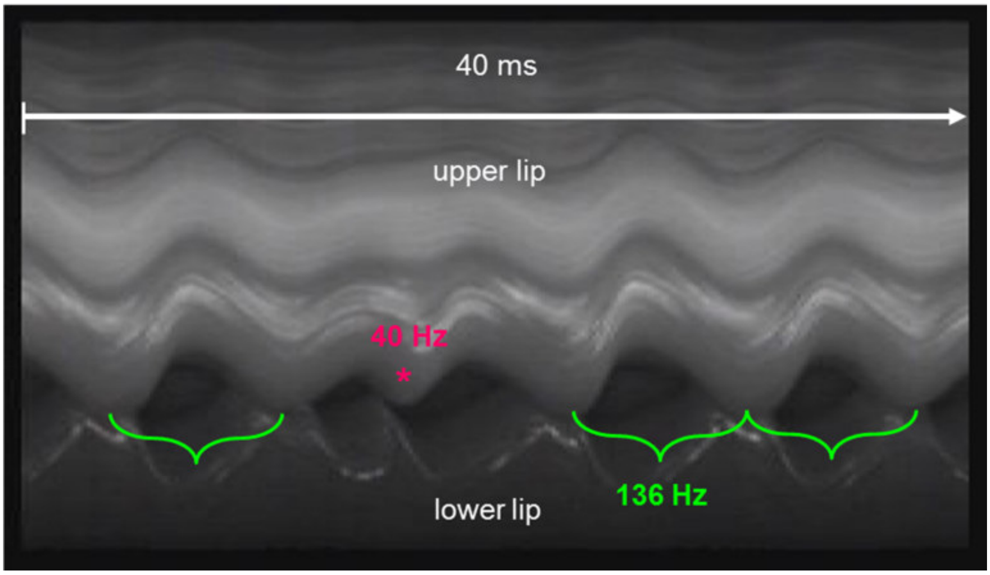
When playing a subcontra G-flat (approx. 23 Hz), each lip vibration correlates with a video frame (frame rate 25 Hz). It is possible to watch every single sinusoidal lip vibration (cf. fig. 4a) and also the transition between two subsequent lip vibrations (cf. fig. 4b).



Source: (Mauersberger, 2010)

Figure 4: kymographic frames of the upper lip of a 52-year-old tuba player (subcontra G-flat at mezzoforte); red line = kymographic line; a) single vibration; b) transition between two vibrations

Split tones (as found in “Keren” by Iannis Xenakis) are multiphonic effects on brass instruments. In the present study, split tones were visualised by using kymography. A trombonist played different musical passages containing two simultaneously sounding notes of different frequencies. Both frequencies showed corresponding amplitudes in the kymographic frame (cf. fig. 5).



Source: (Mauersberger, 2016, [12])

Figure 5: magnified view of a kymographic frame of a 53-year-old trombonist, playing split-tones at mezzoforte; red asterisk: 40 Hz (E♭1); green brackets: 136 Hz (D♭3)

During the kymographic video recording, the software rpSzene® (rpSzene® version 8.0 [2006-2010]/RehderPartner GmbH/Hamburg, Germany) simultaneously registered the audio signal of the trombone. In fig. 5 the sounding notes were D♭3 (136 Hz) and E♭1 (40 Hz). The upper and lower lips changed frequency synchronously, with no phase difference.

4 Conclusions

Kymography is a non-invasive imaging procedure for real-time observation of vibrating lips. By using mouthpieces with probe holes for the endoscope, motion artefacts and air leaks (which occur when playing with a visualizer) can be avoided. Medical practices and clinics providing specialised services for musicians can use these technique for an assessment of brass players' embouchure in cases of posttraumatic injuries or overuse syndromes.

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