TWO ASPECTS OF TRUMPET-PLAYING

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ABSTRACT

In the first part the results of an investigation of trumpet mutes are presented. The author demonstrates the influence of several trumpet mutes on the timbre, intonation, sound radiation and responsiveness of trumpets. The second part deals with a recently started approach in Vienna to get new information about the embouchure of brass players: the “human sound generator” is subject of uncommon cinematic studies. The factors influencing the lip action are so numerous that no quantitative theory can be formulated without further experiments.

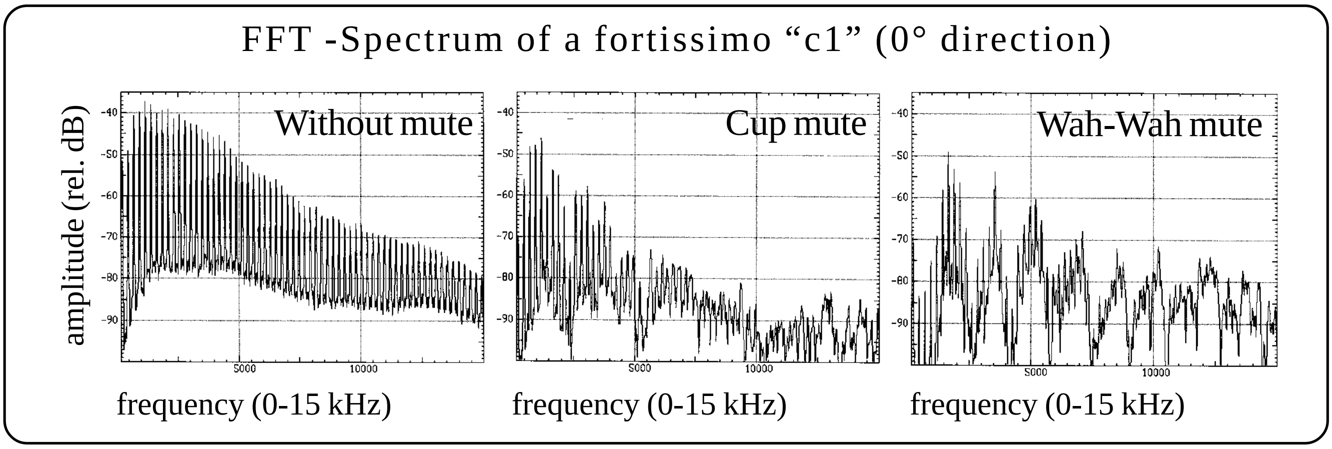
PART I : TRUMPET MUTES

types - dynamics - timbre- response - intonation - sound radation

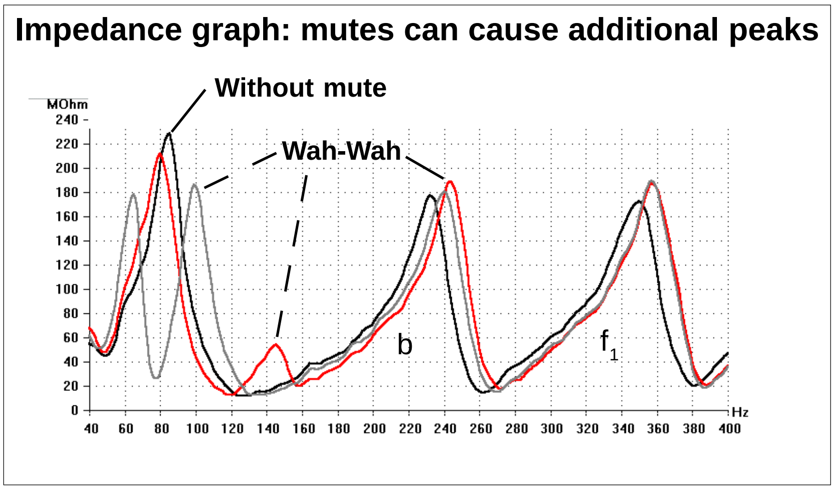
Types: brochures reveal many types of mutes. Surveys of the author result in a ranking list of types which are in use. **1. Cup** (93 % of using); **2. Straight** (92%); **3. Harmon** (75%); **4. Plunger** or anything alike (44%); **5. Wah-Wah** (40%); **6. Velvet** or Bucket (22%); **7. Whisper** (8%); **8. Hat** or Derby) (6,%); **9. Mega-Clear-Tone** (3,%); **10. Buzz WOW** (3%); **11. Mel-O-Wah** (2%); **12. Pixie** or Snubtone (2%) *[The Practicemute (47 %) is out of ranking, because different types are used as Practicemute]*. The six most-used mutes have been subject of an acoustical investigation.

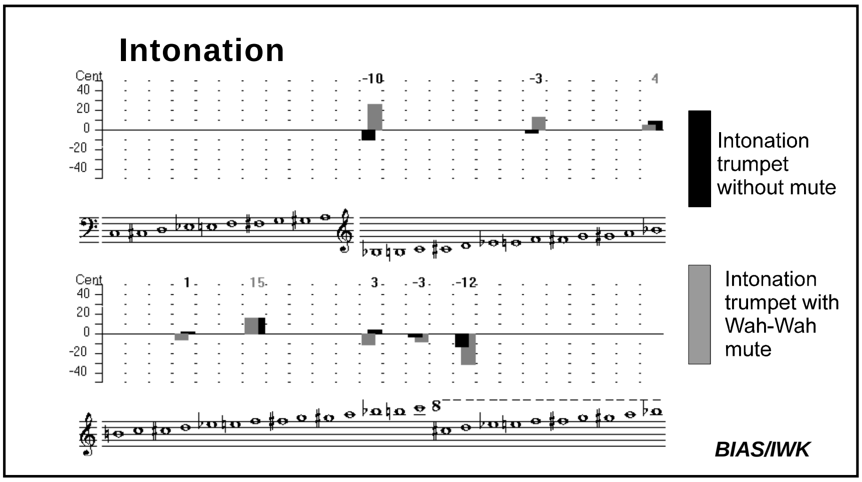
Dynamics: The dynamic range of the trumpet without mute depends on the register: about 30 phone in the lower and about 13 phone in the upper register (Meyer/1980). Measurements of a crescendo-tone in the anechoic chamber of the IWK reveal dynamic range values for the lower-register (written c1). The reference-amplitude 0 dB corresponds with the ppp (as soft as possible) on the trumpet without mute. The dynamic range of the trumpet without mute and with the plunger almost opened is about 30 dB. The Cup, Wah-Wah, Straight and Velvet Mutes have reduced dynamic ranges of about 24 dB. The Plunger has 21 dB at the almost-closed position and the Harmon reduces the dynamic range to 17 dB. The ability to play softer with a mute is only valid for the Cup, Wah-Wah, Straight and Velvet and Harmon mute. The ppp (as soft as possible) sounds -5/-8 dB lower than with without mute. The chance to play fff (as loud as possible) is extremly reduced with the Harmon. A fff is 20 dB weaker than without mute. This explains why the Harmon mute is usually amplified when it is in use. The fff played with Cup, Wah-Wah, Straight or Velvet mute is 12 dB softer than without. The dynamic level of the Plunger depends very much on the gap size. Almost closed (1cm gap) the fff is about 6dB lower than without mute.

Timbre: The sounds produced by some mutes are very characteristic, others sound similar. Physical reasons for a particular timbre are changes in the spectrum. Mutes cause typical formants and above all antiformants. The FFT-Spectrum of the Trumpet without mute is shown in the graph (tone written “c1”, blown fortissimo). The formant area is around 1.2-1.5 kHz. The intensity of higher partials diminish gradually. The FFT of the Cup mute indicates antiformants at 2.5 and 5 kHz. Also to be seen are the weakened partials over 10 kHz. The Cup prevents the radiation of wavelenghts shorter than the dimension of the mute. Very characteristic is the "Donald Duck" sound of the Wah-Wah mute. The FFT shows the alternating formants and antiformants. The foundamental is very faint. The strong partials around 1.5 kHz entail the nasal timbe. Some more examples for particular characteristics of other types: The "classical" Straight mute has weak low partials, a formant around 2 kHz and an antiformant at 4 kHz. The Velvet produces no antiformant or formant. It darkens the sound by attenuating generally high frequencies. (Frequencies with small wavelengths disappear in the cotton wool bucket). The Formants of some mutes correspond with vocal formants. E.g. the Harmon sounds like"ee"(it nickname is bee) and the Plunger sounds in the closed positition like "oo" (doo-wah discribes the closed-open onomatapoeicly).



Response: Impedance-measurements display the influence of mutes on acoustical behaviour. All investigated mutes - except the Velvet - add an additional resonance peak to the curve. This peak causes a shift-effect on further resonance peaks. The dimension of the shift depends on the positon and magnitude of this additional peak. Good specimens of the Cup-, Straight-, Harmon,- Wah-

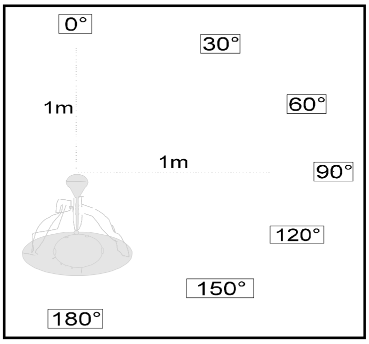


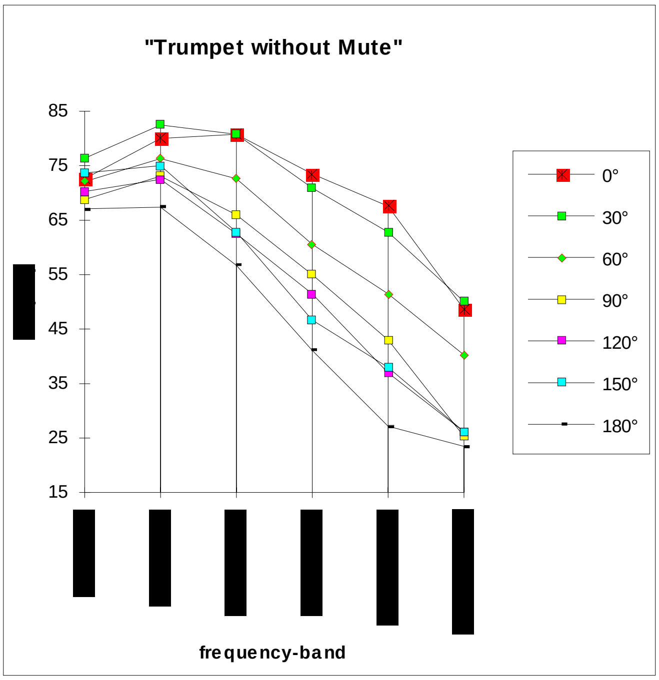


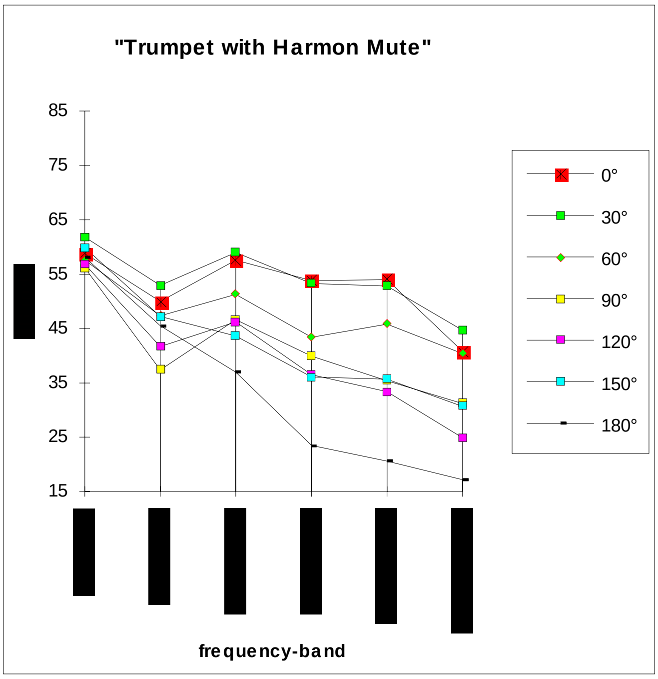
Wah,- mute push the peak below the playing range of the trumpet, and the unwanted shift is less disturbing. Bad specimens shift, and even suppress resonance peaks of the lower register considerable. The additional peak caused by the Plunger (closed position) is located within the playing range and prevents the sound generation of a "correct" musical pitch. That doesn´t matter, because the Plunger is mostly used for special effects like the "growl-technique".

Intonation: The shifts of the resonance-peaks described above influence the intonation. The graph shows one example. In the lower register the trumpet with Wah-Wah mute is much sharper than the trumpet without mute (28 Cent above the values of the equal temperature scale instead of 10 Cent below).

Sound Radiation: The radiaton of the trumpet is more or less affected by the use of different trumpet mutes. Measurements with seven mikrophones *(see illustration)* in the anechoic chamber at our Institute allow the analysis of the radiated signal energy in different frequency bands. The two diagramms below show the RMS recorded at the seven positions in 6 bands for the trumpet without mute and the trumpet with Harmon mute.





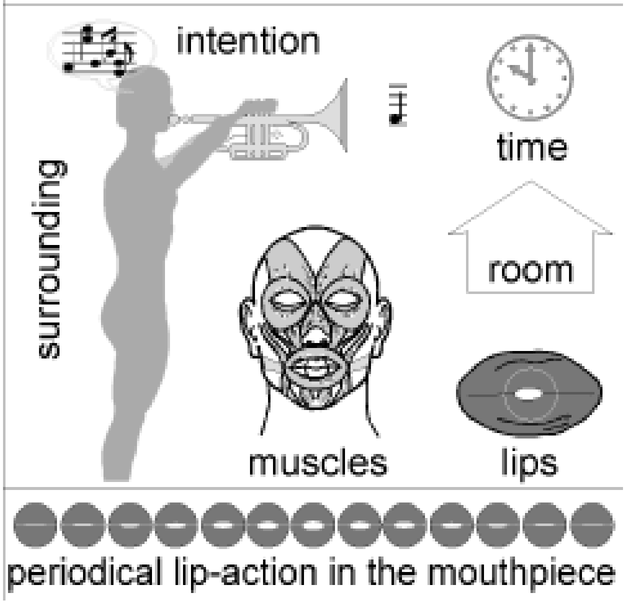


PART II: ON EMBOUCHURES

General

It is obvious that a note of a defined intensity sounds different on various musical instruments. Nor does one trumpet sound like another. But why does one and the same trumpet not always sound the same? This depends on the different sound generation and individual embouchure set-up of the player. It is caused by the complexity of embouchure. In the first *and last(?)* cinematical study *"Lip Vibrations in a Cornet Mouthpiece"*, Daniel W. MARTIN wrote: *"The factors influencing lip action are so numerous that no quantitative theory can be formulated without further experiments.*" Thats the starting point for a new approach in Vienna.

the actual embouchure (tone generation) and some factors influencing lip action



Two definitions

The embouchure is the interface between the musician and the brass instrument. The term „embouchure" is used in two different ways: On the one hand, this term stands for the on-set of the mouthpiece on the lips and the actual tone generation of the lips. On the other hand there is the meaning of the word in its wider sense: phrases like *"I have no good embouchure today"* or *"Soft-drinks are not good for your embouchure"* indicate two aspects of parameters which affect the player. There exists quite a lot of parameters which influence the "human-part" of the linked system "player-instrument". Scientific approaches on this subject have been made from pedagogical side and from the instrumental-acoustic side. The bridge is missing. In fact, the tone generation is determined by the air flow and the lip action. This principle has been known for many years. What makes the differences between the same note, played on the same instrument (and even by the same player)? Brass player are no determinable machines who can repeat the same MIDI sample every time. Recent investigations in Vienna - using new means to work out more detailed information about the embouchure- will try to explain the phenomenon. First some examples of parameters which influence the sound generation of a brass player:

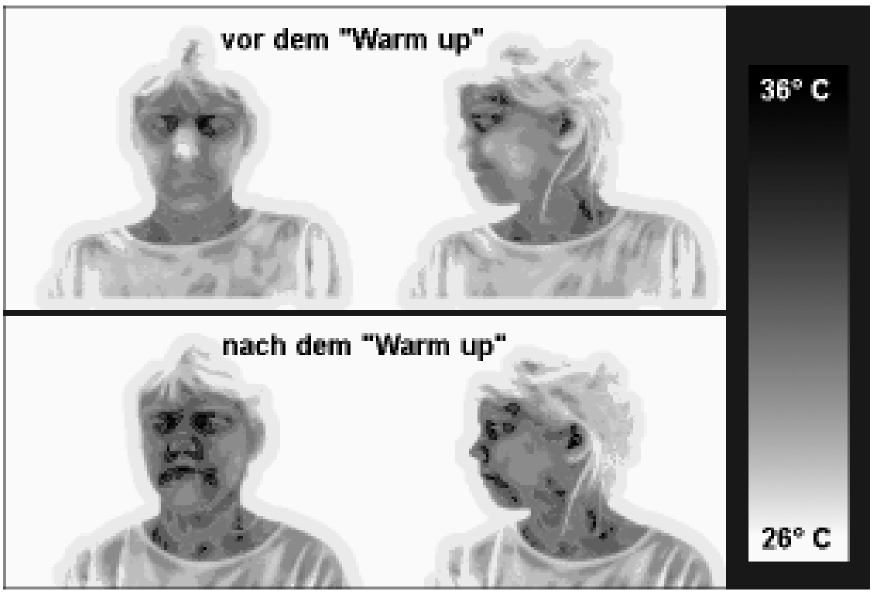
general conditions (social and cultural background; environment): - ability (*more talented / less talented)* - age - education level (*pupil / student / professional*) characteristics of school and teacher (*Vienna / French / German)* - room *(outside / inside; room acoustics)* - environment *(alone / in front of orchestra)* - Instrument (*response; intonation*; *quality)*

physiological conditions: - teeth constellation. - lung capacity - temperature - auditory-system (*hearing-ability*) - constitution of lips and mucous membranes (*"warmed-up / not "warmed-up")* - endurance (*more pressure / less pressure*) - muscles *(relaxed / forced)* - breathing (air-flow) -dynamic - register *(upper / lower)*
psychological conditions: - condition, frame of mind *(day / night; morning / evening; hungry / not hungry)* - intention (*music-context; classic / jazz / else*) - motivation (*sympathy / antipathy*) - cognitive processes - feeling *(familiar with mouthpiece and instrument?)*

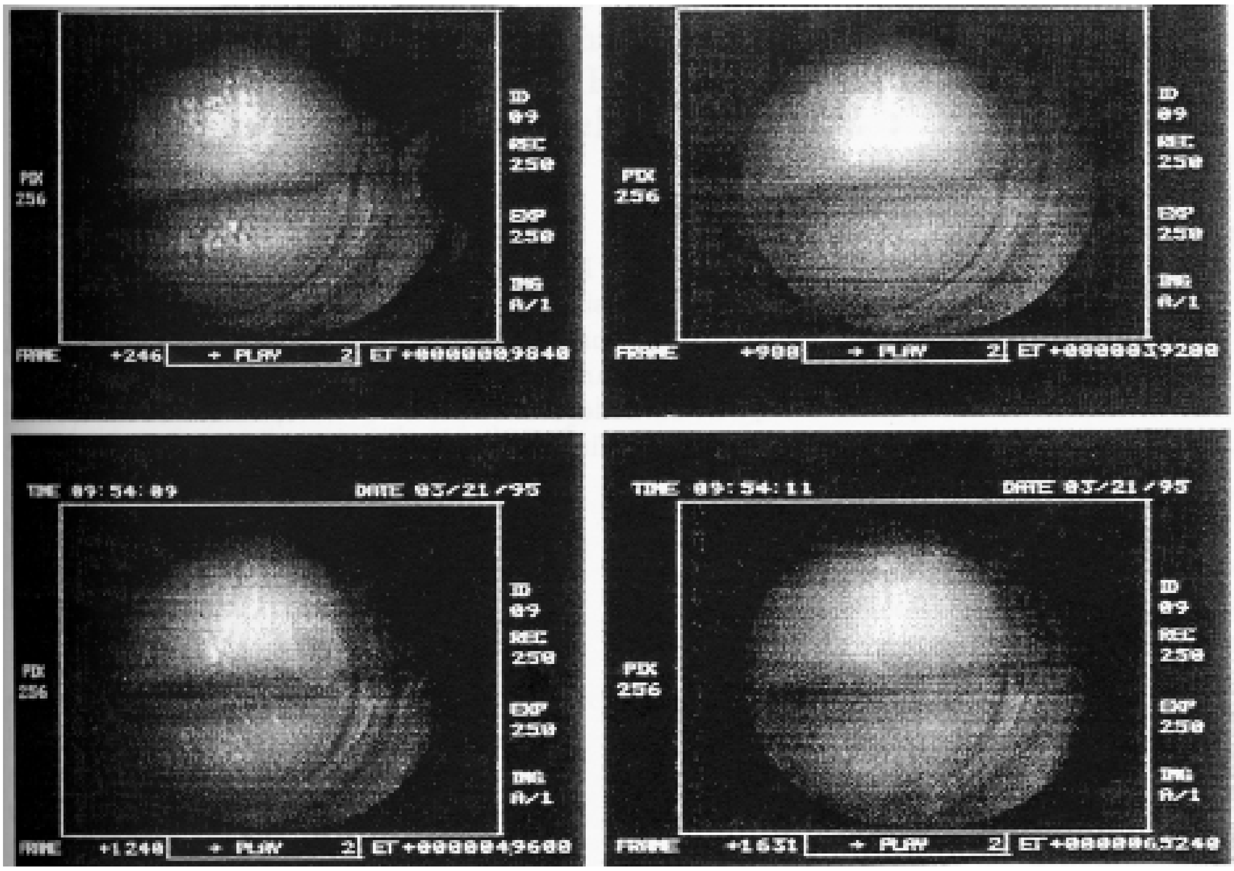
Tests with an "Infrared Camera"

The "Warm up" phenomenon is one subject of the studies recently started in Vienna. Preliminary tests with an infrared camera show actually interest changes in the surface temperature of the players skin caused by warming up. The picture below shows the author before and after he "warmed up" on a trumpet for 5 minutes in the low range. On the left hand side you can see brighter parts of the face than on the right hand side. It can be seen that some parts of the face get warmer than other. The greyscales express the temperature in 1° Celsius steps from white (below 26.6° C) to black (above 36,6° C). [Actually the scale consists of differnt colours] The shootings have been made with Dr. Anton Stabentheiner (Institut for zoology, University of Graz). The aim of further analysis is to reveal the coherence of the surface temperature and the muscle activity. Meantime the question rises up: Is the muscle activity the main reason for the rise in temperature ?

Infrared pictures of a trumpet player before and after a short "warm-up" (dark = warm)



"*High Speed Video*" pictures from vibrating lips
filmed with an endoscope inside the trumpet mouthpiece



Inside the moutpiece

Another approach to reveal new information on the embouchure is to film the vibrating lips inside the mouthpiece. Preliminary experiments from the author, together with Wilhelm Ziegler (ÖWF, Vienna) and Oliver Redl (USI, Vienna) have been made with an endoscope introduced lateral in a trumpet mouthpiece. The signal has been recorded with a "High Speed Video Camera " with up to 1000 pictures per second. The pictures shown above has been filmed with 250 pps and demonstrate a written "c1" (235 Hz) blown with four increasing dynamic levels. (top left: pianissimo , right: piano; bottom left: mezzoforte, right: forte). You can see an increasing aperture of the lips during louder sound generation (the blurred parts of the lips increase because one picture shows a whole cycle of the period). Aim of further experiments -using "stroboscope technique" - is to define the excitation spectrum through optical methods.

References: - BACKUS, John. Input impedance curves for the brass instruments. (in: JASA, Vol 60, No2. 1976) - BERTSCH, Matthias. Der Einfluß des Dämpfers auf das akustische Verhalten und die Klangfarbe der Trompete. (Dipl.-Arb.,Universität Wien 1992) - KURKA, Martin. A study of the acoustical effects of mutes on wind instruments. (Chicago, 1961) - MARTIN, Daniel W. Lip Vibrations in a Cornet Mouthpiece (1942) - SLUCHIN, B. CAUSSÉ, R. Sourdine des Cuivres. (Paris, 1991)