DOUBLE-REEDS IN THE WIND CAPSULE – TIMBRAL CONSEQUENCES OF THE MISSING ACCESS OF THE MUSICIAN

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ABSTRACT

The Bernoulli principle is responsible for the sound of woodwind and brass instruments, as well as singing and speech voice. Connected with the periodic opening and closing of the (double) reeds or lips is a characteristic cyclic structure of the spectra of these tones.

However, the Bernoulli principle is not responsible for the frequency-constant position of the spectral maxima and minima, which are typical for the (doule) reed instruments of the modern orchestra.

In case of the modern double-reed instruments the sound organization is controlled by the musician because he can influence the movement of the double-reeds with his lips and the air-flow pressure. If this controllability is void by the use of a wind capsule, the spectra should not have frequency-constant maxima. It is the aim to prove this at wind capsule instruments.

Tones from the scales of a krummhorn, kortholt, rackette and Rauschpfeife have been analyzed via FFT and compared regarding to their spectral envelopes.

The proof, that the spectra of these instruments have irregular or pitch-dependent structures instead of frequency-constant maxima and minima, leads to the conclusion, that the removal of the wind capsule did not only enable a new dynamic play for the musician, but also a completely new and constitutive feature of the timbre:

The principle of pitch independend formant areas, which is not at all natural for double-reed instruments, was realized here. Without this principle the differentiation and blending of timbres of the instruments of the modern orchestra would not be imaginable.

In the renaissance age the voice differentiation of instruments playing together followed another principle, which consists of phenomens like the residue, stream segregation and continuity illusion.

1. BACKGROUND

The Bernoulli principle is responsible for the sound of woodwind and brass instruments, as well as singing and speech voice. The basis of the sound production are pulses, resulting from the periodic opening and closing of the (double) reeds and lips (FRANSSON 1967, 25-27; VOIGT 1975, 208 f.).

Connected with the periodic opening and closing of the (double) reeds or lips is a characteristic cyclic structure of the spectra of these tones. However, the Bernoulli principle is not responsible for the frequency-constant position of the spectral maxima and minima, which are typical for the (doule) reed instruments of the modern orchestra (FRICKE 1975, 407-411; FRICKE 1989, 113).

2. AIMS

Beside the control of the air pressure, in modern (double) reed instruments there are three additional parameters which influence the oscillations of the reed(s): lip pressure, the contact point of the lips at the reed(s), and the volume of the mouth cavity. As the musicians removed the wind capsules of their instruments and took the reeds between their lips at the end of the renaissance age, they produce a more modulationable sound with less partials, due to the damping of the reeds by the lips. If this controllability by the use of a wind capsule is void, the dynamics are limited to ± 2 dB and stable formants are missing in the spectra. The spectra do not even have the attributes of frequency-constant maxima, because the irregular opening and closing procedures of the reeds produce impulses, which lead to irregular cycles in the spectra.

3. METHOD

Typical wind capsule instruments like bass and soprano krummhorn, kortholt, rackette, and the pipes of a bagpipe has been played by an experienced musician, a long time member of an ensemble for old music. The tones of the entire range of the instruments have been analyzed via FFT and compared regarding to their spectral envelopes. The results are compared with the sound analysis of a shalm played without a wind capsule.

4. RESULTS AND CONCLUSIONS

1. In most of the spectra one can find several cycles interlocked into one another, as they are known as results from pulse trains, which pulses are formed by flanks with different steepnesses. This is true to (nearly) all pitches of the instrument, even in the upper range. Here one can see a substantial difference in the comparison to the clarinet (which is an instrument with more than one register). The depth of the even-numbered gaps amounts up to 36 db and gets weaker toward higher partials, until the gaps dissapear in the second or (at low-pitched fundamentals) third octave, because the amplitudes of the even-numbered partials become more and more stronger with higher frequency. Occasionally, above this place in the spectrum, one can see inversions of this principle: series of even-numbered partials are getting stronger than the odd-numbered partials. Due to the distinguished odd-numbered partials a zigzag pattern arises in the

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lower part of the spectra, which shifts more or less continuously together with the fundamental to higher frequencies. Thereby the fundamental is mostly the strongest. This speaks against a developement of stable formant areas.

2. The spectra of all instruments have a distinctive cyclic structure, which is characterized by deep gaps in the envelope. These gaps are small: usually they are formed only by one withdrawing partial, rarely by two, and they are low in amplitude: they are often around 24 db, in individual cases to 46 db below the level of the adjoining partials. But acoustically they have not a so large effect as it seems, because of the masking effect of the adjoining partials.

Comparing the spectra one can see that sometimes the gaps in the envelope are connected to certain partials so that they raise and fall with the fundamental. But sometimes the gaps are stable and independent from the fundamental, as it is described by the theory of absolute formant areas (FRICKE 1989, 109-118). This inconsistency is a further reason to say that there are no formant areas between the gaps of the spectral envelope. Also a vowel-like timbre, which could be an indication for formant areas, does not exist. Sharp timbres prevail due to the large amount of 60 and more partials

3. One can see in most of the spectra several cycles being interlocked into one another. This is a well known picture caused by pulse trains consisting of pulses which have different steepnesses of their front and rear flanks (AUHAGEN 1987, 709-712; BLENS, FRICKE 1994; 965-968). One main cycle interferes with one sub cycle. The main cycle is subdivided by the sub cycle, as it is known by piano spectra (FRICKE 1985, 439-442).

Furthermore the principle of imparity interferes with the principle of the cyclic gaps in that way, that sometimes the first dominates and sometimes the second one. When a spectal gap caused by a cycle meets a spectral gap caused by the weaker even-numbered partials, the effect of both phenomena gets even stronger, so that the resulting gap can reach a depth of 50 db.

The spectra of the bass krummhorn (G) and of the tenor kortholt (A) are two examples, which may stand for the whole of the analyzed tones.

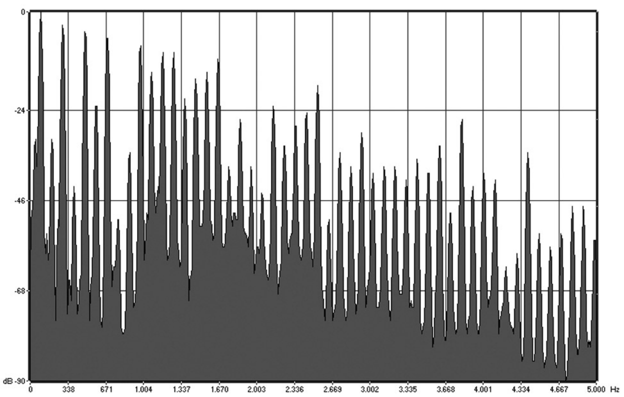

Figure 1: bass krummhorn (G)

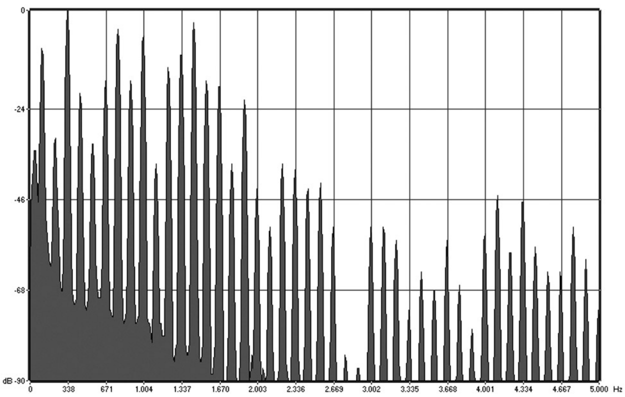

Figure 2: tenor kortholt (A)

It becomes clear in the case of the shalm that the result can also look completely differently. In the spectra of this conical double-reed instrument, which has been played without a wind capsule, the stable formant areas appear obviously at 1200 and 2700 Hz.

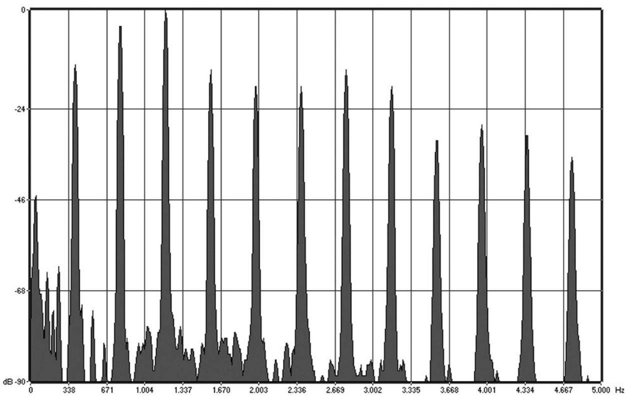

Figure 3: shalm (g^1)

4. The proof that the spectra of the wind capsule instruments do not have stable formants, but irregular envelopes or envelopes moving along with the pitch of the fundamental, leads to the following conclusion: the displacement of the wind capsule enabled the musisian not only to controll the reeds and to play the instrument dynamically, but it introduces also a completely substantial and new feature of the instrument timbre: The principle of pitch independend formant areas was realized here, which is not at all natural for double-reed instruments (FRICKE 2003). Without this principle the differentiation and blending of timbres of the instruments of the modern orchestra would not be imaginable (REUTER 1996).

In the renaissance age the voice differentiation of instruments playing together followed another principle. It was the residue, which was made possible by the strong segmentation of the spectra of the instruments at that time, supported by stream segregation and continuity illusion. It was the intention to listen to the linear melodic lines of the musical piece, but not to recognize the instruments. They were exchangeable ad libitum.

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