INTERDISCIPLINARY PERSPECTIVES ON PLAYING AN INSTRUMENT: DOES THE SHAPE OF A RECORDER MOUTHPIECE INFLUENCE THE TIMBRE?

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ABSTRACT

This paper looks at the connection between the player and his or her instrument using the example of the recorder. Does the shape of the mouthpiece change the sound of the instrument, and if so, which frequencies are changed? In this survey, three people were recorded playing the same instrument with two different shapes of mouthpieces, the traditional shape and the other with a plastic ‘hat‘ to change the shape of the mouthpiece. (The ’hat‘ had been developed by the author with the support of Stefan Kopp, professor of ortodontics.) The frequency spectrum of the recorded notes both with and without a hat was then analyzed. The spectra showed some differences. Their frequency area depends on the presence of a ’hat‘ and on the register of the played note. The results open new perspectives for interdisciplinary research (musicology, medicine and acoustics) to understand better the process of playing an instrument.

1. INTRODUCTION

While the recorder maker is usually responsible for the construction and maintenance of the instrument, the player is in control of its use. But in order to produce a sound, the player needs to connect with the instrument, and this area of connection is the subject of my investigation. To prevent air escaping from the sides of the mouth, it is necessary to seal the junction between the lips and the mouthpiece. This entails that the shape of the lips is determined by the shape of the recorder mouthpiece, and the lips are connected to the rest of the body, the movement of the lips is connected to the movement of other parts of the body as well.[1] Jer-Ming Chen, Dan Laurin, John Smith and Joe Wolfe have shown in their work concerning the vocal tract interactions in recorder performance, that the tensions in the mouth influence the sound of the instrument [1]. Putting all these premises together, it is highly probable that the shape of the mouthpiece has an influence on the sound of the recorder.

The idea of fabricating individualized mouthpieces for the recorder is not completely new. For example, there is the concept of the two opposite breathing types which, according to this theory, requires different shapes of mouthpieces [2]. During my experiences as a teacher, I have observed more than two different breathing and playing types. Every person has different body proportions. This matters especially for the proportions of the face and inside of the mouth – the areas that connect most with the instrument. It is quite normal for brass players, for example, to choose a mouthpiece that fits their physical condition.[2]

Figure 1. Recorder at A=440Hz made by Ralf Netsch after a model by Denner, with ‘hat’. Photo by Naomi Nordblom.

With these considerations in mind, I have been developing new shapes of mouthpieces. Beginning in 2011, I have modelled them with dental silicone and have then tested the results in my daily practise routine. Since these mouthpieces sit on the top of the headjoint, I call them ‘hats’. To avoid changes in the shape of the soft silicone mouthpieces, the experiments were made with 3D copies

[1] I am grateful to Professor Stefan Kopp, Johann Wolfgang Goethe-Universität Frankfurt am Main, for his advice.

[2] See for example the wide variety of brasswind mouthpieces offered for sale on the website of Bernhard W. Schmidt [3].

of the hats in ABS plastic (see Figure 1). During these experiments, I noticed not only a different feeling in the mouth, but also that some playing properties of the instrument changed as well: the timbre was more brilliant, and the notes responded more quickly. To separate opinions from facts, it is important to examine the changes in the playing properties of the hats with recorders. In this survey, I have recorded the sound of the recorders and their hats to evaluate the results with a frequency analysis and to estimate the influence of the parameter ‘shape of the mouthpiece’ on the playing properties of the instrument.

2. THE EXPERIMENT

In a soundproof room, the sound recorder (model ZOOM H2n) was placed with enough distance from the playing position, so that the usual playing movements of the player did not influence the recorded sound (distance 9.19ft). The apparatus for the experiment is shown in Figure 2.

Figure 2. Apparatus for the experiment, showing (A) sound recorder, model ZOOM H2n, (B) phone with metronome app bestmetronome and headphones, (C) f-alto recorder at A=415Hz by Doris Kulossa, (D) f-alto recorder at A=440Hz by Ralf Netsch. Photo by Naomi Nordblom.

Before each recording, every player receives three minutes to become accustomed to the instrument with and without a hat. First, a F major triad is played throughout the whole range of the instrument (f^1, a^1, c^2, f^2, a^2, c^3, f^3), then, two notes are chosen from this material for further analysis of the results. This relatively large amount of data helps to avoid conscious or unconscious manipulation of the sounds, as this would be more difficult over a long time span than over a short one. Additionally, the notes chosen for further interpretation are not known to the players. To make further analysis easier, every player wears headphones with a metronome marking of MM=100. Every note is played for a duration of four beats followed by two beats of rest, first with a hat and then without. Then, the recordings are converted with the software ‘Audacity’ to make them available for further evaluation with ‘Sonic Visualiser’, a program that shows the spectra of the recordings. For the evaluation of the results, the second note of each recording and pitch was selected during the steady state. The overtones shown in the spectrum and their relative amplitude to each other give some indication of the specific timbre of the played sound [4:31].

Formant	Frequency area (Hz)	Sound quality
u	200-400	large sound
o	400-600	
å	600-800	
a	800-1250	poweful
ö, ü, ä (+o,a,u)	1250-1800	nasal
e (+o)	1800-2600	bright, brilliant
i (+u)	2600-5000	

Table 1. Relationship between frequency and timbre after Meyer.

The timbre of wind instruments is mostly determined by the formants [5:401], which are fixed areas of the spectrum that are responsible for particular properties of the overall sound. These have been shown to correspond to the specific coloring of the vowels (e.g. different pronunciations of ‘fork’ and ‘bone’). The relationship between frequency and timbre can be seen in Table 1 [4:33-34]. With a hat, a recorder sounds more powerful and brilliant. us, increased frequencies between 800Hz and 1250 Hz and above 1800Hz are expected.

This experiment requires several test series. The main test series consists of two notes (f1 and c3) played on the f-alto recorder in A=415Hz made by Doris Kulossa after a model by Jacob Denner. Three different test subjects are being recorded. Apart from the main test series, there are two control test series. The first control test series consists of the same procedure as in the main test series, but with a different instrument, a f-alto recorder in A=440Hz made by Ralf Netsch after a model by Denner. The second control test series uses the same instrument as in the main test series, but the recordings are taken on three consecutive days and always involve the same player. This series is important to examine whether the results are reproducible and to estimate the margin of error of the main test series.

3. RESULTS

The results consist of the spectra of the played notes of which an example is shown in Figure 3. The blue graph shows the spectrogram with a hat and the green graph without one. To compare the results of the recording with a hat to the recording without, both graphs were reproduced overlapping each other. As some parts of the graph below are hidden, every measurement contains two pictures: one picture with the green graph in front (so that the blue overlap shows the extra frequencies with a hat) and one with the blue graph in the foreground, so that the green overlap shows the supplementary frequencies without a hat. Full backup data may be accessed on the author's website:

<https://recordermouthpieces.wordpress.com>

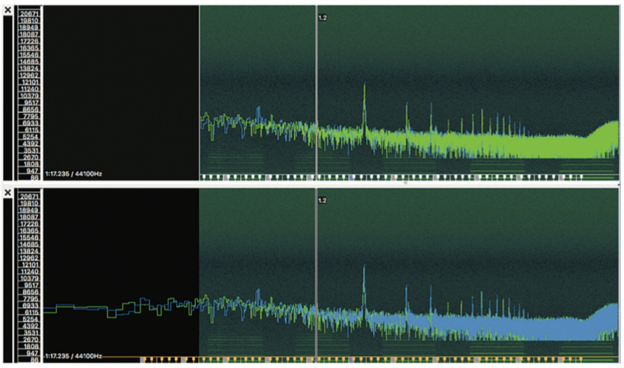

Figure 3. Spectrum of the note f^1 using a recorder at A=415Hz without (upper part) and with (lower part) a 'hat' in front.

Concerning the main test series, all three results for f^1 show a significant increase in the amplitude of the overtones between about 3000Hz and 5300Hz with a hat (see for example the upper part of Figure 3) which makes a more brilliant sound. Two of the three test subjects showed a slightly louder fundamental with the 'hat' (see Figure 3). For the note c^3, all three players had a louder fundamental with the 'hat'. Two of the three measurements with the 'hat' show amplified overtones between 4500Hz and 12700Hz, making the sound more brilliant. Two of the three players also show a louder first overtone without the 'hat'; its frequency is about 2000Hz.

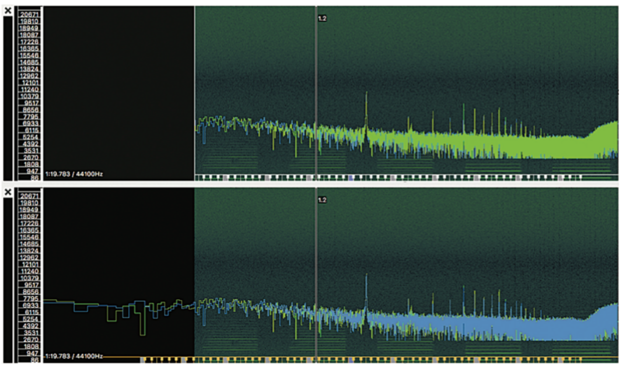

Figure 4. Spectrum of the note f^1 using a recorder at A=440Hz without (upper part) and with (lower part) a 'hat' in front.

The first control test series was carried out with a different instrument. As the hats are handmade, the shapes of the mouthpieces for the two alto recorders are not identical and neither are the two recorders. Thus, the results of the two 'hats' should not be compared to each other, but rather to the corresponding measurement without a 'hat'. All three measurements of f1 show amplified overtones between 3760Hz and 4140Hz with a 'hat' (see Figure 4 in the color section, upper part), making the sound more brilliant. The highest overtone with a 'hat' is a little bit louder than the measurement without a 'hat' (Figure 4, upper part). The place of this highest overtone depends on each individual person and lies within the range 5150–6600Hz. All three recordings of the note c^2 with 'hat' show bigger amplitudes from the second overtone upwards. is corresponds to the frequencies above about 3150Hz, and makes the sound brighter and more brilliant.

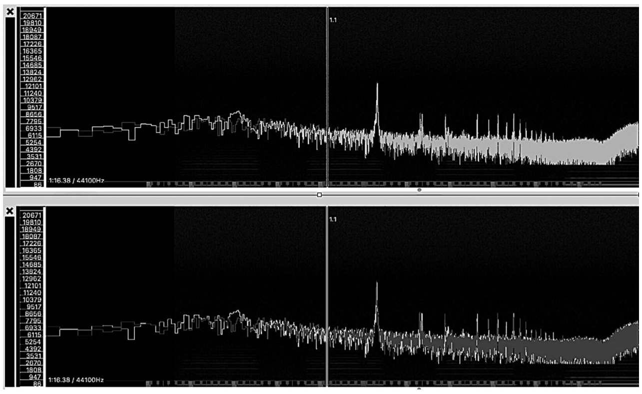

Figure 5. Spectrum of the note f^1 using a recorder at A=415Hz without (upper part) and with (lower part) a 'hat' in front, second control test series.

The second control test series was made with a 415Hz recorder on three consecutive days. This test series is particularly important to show if the results are reproducible, and to estimate the margin of error. The frequency analysis of f1 shows also amplified overtones between 3000Hz and 5300Hz with a 'hat' as in the main test series (see Figure 5, upper part). The slightly louder fundamental with a 'hat' is not present here. For c3, the louder fundamental and the weaker first fundamental with 'hat' are present on all three days.

To reduce noise from the outside, all the recordings were made in a soundproof room, with the result that some minor differences might be muffled by the walls. All the spectra show some background noise with frequencies above 13000Hz, a range that can hardly be heard and does not lie in the range that is interesting for our measurements, and so has no influence on the results of the experiment. Moreover, the number of three participants is rather small; under the available circumstances it was not possible to interpret larger amounts of data. As the control test series gives reasonable and reproducible results, the possibility for errors seems to be quite small.

4. CONCLUSIONS AND OUTLOOK

The proportions of the amplitude of the overtones determine most of the timbre. The presence of a 'hat' and the changed shape of the mouthpiece of the recorder changes the proportions between the amplitudes of the overtones. It is arguable, therefore, that the shape of the mouthpiece influences the sound of the recorder. To estimate the exact amount of this parameter and to examine its effects on other playing properties (such as articulation and the register changes) further studies with recording studio conditions and with more test subjects are needed. Instrument makers could incorporate the parameter into the design of the instrument. The results are important for music teachers: a 'bad' body position of a pupil might not be caused by a 'lack of talent', but perhaps by an instrument that does not fit his or her physical characteristics. Moreover, performers can explore new sound possibilities on their instrument. Indeed, this issue might also occur with all the other wind instruments that have a close connection between the mouth and the mouthpiece. The results suggest that there is a causal relationship between the shape of the mouthpiece and the resulting sound on the recorder. I hope to have taken a first step into examining the possibilities that the shape of the mouthpiece provides for instrument makers, performers, and teachers.

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