INVESTIGATING THE INFLUENCE OF BLOWING TECHNIQUE ON PITCH AND TONE IN RECORDER PLAYING

Niels Bak

1. Experimental conditions

The investigations to be reported here are concentrated about two main aspects:

1) analysis of the acoustical properties of the tone

2) the physical/physiological aspects, or the way the player blows his instrument.

These two aspects make different demands on room conditions and experimental setup.

The acoustical investigations - based on microphone signals - make special demands on the properties of the recording room as well as on the quality of microphone and tape recorder. All recordings of this kind were made in a sound treated room.

These demands are of secondary importance only during the physical/physiological investigations, which aim at an exact and detailed registration of variations in blowing pressure synchronized with continuous X-ray recordings of the pattern of movements in the mouth and pharynx during play. Internal television equipment was used for the latter recordings.

2. Pilot experiments

Partly in order to gain some experience in the use of unfamiliar equipment, and partly in order to test the validity of information found in current scientific and pedagogical literature, some pilot experiments were first carried out. These ex-

periments confirmed that

1) the humidity of the air, which during natural blowing condenses to water on the inside of the bore of the recorder, has a strong influence on the tone of the recorder. After a very short period of blowing a "dry" recorder the tonal spectra of the notes show an increasing intensity of higher harmonics (keeping blowing pressure and other factors constant).

2) an increase in blowing pressure increases the relative intensity of higher harmonics.

3) when a recorder player repeats a note choosing a new vowel position for every new attack, the blowing pressure is in almost all cases involuntarily changed, even if he takes pains to keep it constant. This applies even to experienced professional recorder players. Thus one subject who was given the opportunity to read the frequency from the frequency counter while playing was unable to prevent the frequency from rising during the articulation of [i] and falling during the articulation of [u]. Simultaneous pressure recordings show that the changes in frequency were due to variations in blowing pressure (cf. Bak 1970). However the variations seem to depend to a considerable extent on the schools and systems employed.

It should be noted that for technical reasons the blowing pressure quoted in Bak (1970) is defined as the air pressure in the mouth cavity just in front of the mouthpiece when the lip opening is not narrowed to a degree which might offer noticeable resistance to the air stream. This reservation must be made since lip resistance - which forces the player to increase the air pressure in the mouth cavity if the pitch is to be kept constant - is a parameter that is difficult to control.

However, since the lip function with the professional recorder player appears to be a more important factor than has so far been assumed, coming investigators are recommended to measure simultaneously the pressure in the mouth cavity and in the windway of the recorder.[1]

3. First series of experiments: Investigation of the influence from mouth and throat cavities on tonal quality and pitch

Much could be said for the use of natural blowing of the recorder, meaning that the recorder is blown by a subject. Thus a number of pedagogues (with whom on the long view a dialogue would be desirable) are notoriously suspicious of how far mechanical blowing provides an adequate substitute to the assistance of a musician. However, the pilot experiments had shown that natural blowing entails a number of problems in technique of measurement - problems which are of less prominence if the recorder is blown mechanically. The latter procedure was therefore used in all cases except in the two first experiments of the series. The whole series of experiments was arranged on the assumption that if, as is commonly held to be true, the musician may influence tone and pitch appreciably by changing the resonances of the mouth cavity, it should be possible to register this same tendency by using a mechanical blowing technique via an artificial mouth. In the first experiment the subject played the same notes three times with changing vowel

---

1) Information on the pressure in the windway can be used to calculate the particle velocity of the air stream which is sent towards the lip of the recorder. This is of great importance to the understanding of the acoustical system of the recorder; and by comparing the pressure differences between mouth and windway much information can be gained on the activity of the lips during play, since the fall in air pressure from mouth to windway will indicate the degree of narrowing in the lip opening.

positions, namely [a], [i], and [u]. In this case the subject succeeded in keeping the blowing pressure relatively constant. In the second experiment the resonances of the mouth cavity were changed during every other note by alternatively playing with and without a wad of cotton-wool in the front part of the mouth. The following experiments were all carried out with an artificial mouth.

It would lead too far to describe here all the changes that were made on the artificial mouth during the following (futile) endeavours to affect tone and pitch by varying the resonance conditions of the artificial mouth. By way of examples may be mentioned: variations in the shape of the "mouth" with an artificial tongue made from plasticine; choice of different degrees of resistance between air tube and "throat-mouth" cavity, i.e. at the "glottis"; use of three different mouth cavities, the dimensions of which (see G. Fant 1960) corresponded to the articulation of [a], [i], and [u]. However, it turned out that none of these manipulations had any effect which could be said to support the "resonance theory". Consequently, this series was terminated with two experiments in which the artificial mouth as a resonator had the highest possible effect: With an artificial mouth, having a cylindrical shape, plane end plates, and a length of 150 mm, the note c‴ was blown. This note was chosen because its wavelength was twice the length of the "mouth". An extra resonator with an adjustable volume was coupled to the artificial mouth, and the tonal spectrum inside the mouth was monitored via a probe microphone.[2] With the help of the extra resonator the tonal spectrum in the "mouth" could be changed, since the amplitude of a given harmonic could be varied with the setting of the adjustable resonator.

---

2) The probe microphone was kindly placed at our disposal by Brüel and Kjær, Nærum, Denmark.

It was found that the pitch and tonal spectrum of the recorder were unaffected by the changes in the tonal spectrum inside the artificial mouth (as conditioned by the adjustable extra resonator) no matter the size of these changes.

A similar experiment was carried out with the note d". In order to adjust the length of the "mouth-throat" cavity to the wavelength of this note a "mouth" with the extraordinary length of 298 mm (= 1/2 wavelength) was used. The probe microphone showed that extensive modifications could be made in the resonance conditions of the artificial mouth. Thus, inside the "mouth" the fundamental of the tone could reach a sound pressure level of 132.6 dB, and by altering the volume of the extra resonater the SPL of the fundamental could be reduced to 93.6 dB. Even this reduction in the energy of the fundamental had no measurable influence on the tonal spectrum and pitch of the recorder itself.

The experiments indicate that it is not possible to affect the playing of a recorder through variations in the resonance of the mouth cavity.

4. Second series of experiments: Investigation of the activities in mouth and throat during play, using X-ray equipment in combination with recordings of tone and blowing pressure

The experiments were carried out at the X-ray department, Copenhagen Dental Hospital, in the middle of January 1972. Eight recorder players participated, representing all stages of experience from the beginner to the artistic player. While the subjects played a previously determined program a continuous X-ray recording of the movements of the mouth, tongue, and throat was made on a video tape in synchrony with a microphone recording of the play. Furthermore, blowing pressure and microphone signal were recorded with the help of equipment borrowed from the Institute of Phonetics.

As yet, all the recorded material has not been thoroughly analysed, but even now it is evident that these recordings offer exceptional possibilities of analysing recorder playing from quite a new angle.

5. Conclusion

From the results of the experiments it can be concluded that:

1) The "vowel theory" claiming that the mouth cavity has a relatively large volume during the play of deep notes and a reduced volume at high notes (articulation of [u] and [i]/[y] respectively) must be rejected.

2) The resonance conditions of the mouth cavity have no appreciable effect on the pitch of the recorder, just as the tonal spectra recorded in the sound-treated room of the Institute of Phonetics reveal no influence from the resonance of the mouth cavity on the quality of the tone.

3) The variations in blowing pressure during play are of paramount importance to the quality of the play. Not only is vibrato caused by variations in pressure, but even the purity of the play depends on how far every note is intoned with exactly the blowing pressure which is characteristic of it. Especially highly skilled recorder players will change the blowing pressure in a meaningful way with an astounding precision - even during rapid passages.

References

Bak, Niels 1970: "Pitch, Temperature and Blowing Pressure in Recorder-Playing", Acustica 22 (1969/70), p. 295-299.

Fant, Gunnar 1960: Acoustic Theory of Speech Production.

Acknowledgements

The research reported in this paper is supported by the Danish Research Council for the Humanities (Statens humanistiske forskningsråd).

Professor Arne Björk at the Copenhagen Dental Hospital has kindly put his X-ray facilities at my disposal, and his photographer has given me highly valuable assistance with the X-ray recordings. The staff at the laboratory of the Institute of Phonetics has been of much help to me in my experimental work. I am particularly indebted to Mr. Carl Ludvigsen for his valuable assistance with the experiments involving use of the artificial mouth. Finally, I wish to thank the recorder players who have kindly allowed me to make X-ray recordings of their play.