Evaluating the Subjective Effects of Microphone Placement on Glass Instruments

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ABSTRACT

We report on a study of perceptual and acoustic features related to the placement of microphones around a custom made glass instrument. Different microphone setups were tested: above, inside and outside the instrument and at different distances. The sounds were evaluated by an expert performer, and further qualitative and quantitative analyses have been carried out. Preference was given to the recordings from microphones placed close to the rim of the instrument, either from the inside or the outside.

Keywords

glass instruments, microphone placement, sound analysis

1. INTRODUCTION

The NIME project at the Norwegian Academy of Music focuses on the development of new acoustic and electronic instruments. As described more thoroughly in another paper [4], we have developed a series of glass instrument prototypes with the ambition of creating a larger and more complex glass instrument. So far this has included the making of bowls of various shapes and sizes, with different types of surfaces, with and without stems, and several types of tools to perform on them. A picture of some of these instruments can be seen in Figure 1, and further documentation is available online.[1]

Figure 1: Examples of glass instruments and tools.

[1] `http://www.nmh.no/nime`

From an artistic point of view, we are interested in creating new instruments that are highly complex and that open for a wide variety of musical explorations. At the same time we are also concerned about creating objects that are durable enough to withstand professional musical practice and concert use. Finally, the objects should also be visually pleasing to look at, so that they can be used on stage and be an attraction in themselves.

So far the development of the instruments has been a creative process in which our imagined sonic and musical possibilities have met with the possibilities and limitations of the glass artists that we have collaborated with. Our experience from the process is that glass is an exciting material to work with, and can potentially lead to great sounding instruments. However, since the process of blowing glass can be compared to that of a live performance, it is not always obvious what the end result will be.

Before creating any new glass instruments, we have started a systematic study of various features of the instruments already manufactured. The aim is to understand more about which features are the most important when it comes to the expressive potential of the instruments in music performance. Our studies include compositional and performance practice with the instruments, and analytical studies of various features.

We have identified the following variables as crucial for the final sounding result, and the musical playability of the instruments:

- Material, shape, size and construction
- Microphone selection and placement
- Tool used to excite the instrument
- Sound-producing action used to excite the instrument

Obviously, these variables co-influence each other, i.e. the final sounding result is based on the combination of all features. For analytical purposes, however, we have found it useful to separate them to evaluate each variable independently. In this paper we will mainly address the second of the variables, and more specifically *microphone placement*.

2. MICROPHONE PLACEMENT

The acoustic sound level of the glass instruments is low, so amplification is necessary to work with the many subtle and complex sonic details that the instruments offer. This means that selection and placement of microphones is of uttermost importance for the final sounding result. Microphone *selection* is in itself a large topic, and will not be addressed in this paper. Rather, the focus will be on microphone *placement*, and how it influences the resultant sound. These are the questions we want to answer:

- How does the microphone placement, and distance from the object, influence the resultant sound?
- How does the stroke position related to the microphone placement influence the resultant sound?

2.1 Amplified sound

Many discussions about microphone placement focuses on questions like close vs. distant placement. Since our goal is to use the sound for amplification and electronic manipulation, we are mainly interested in 'close' sound, and the subtleties that arise from minor adjustments to the microphone placement. Today's listeners are increasingly getting used to amplified sound, both in recordings but also increasingly in concert situations.

This calls for a change of artistic focus for performers, and the need to adjust and experiment with techniques of enhancing the sonic subtleties experienced close to the instrument. Furthermore, when working with electronics in addition to the acoustically generated, and electronically amplified sound, such timbral nuances are important. From such a perspective, microphone placement is not only about amplifying the sound, but rather changing the sonic quality of the instrument itself.

2.2 Evaluating sound

There are many approaches to evaluate the 'quality' of a sound. This can be done through acoustic measurements, perceptual listening tests on a group of people, etc. Our approach is to combine subjective judgement with an acoustic analysis of the sounds. The subjective judgement has been carried out by the second author, a professional percussionist performing with the glass instruments on a regular basis. As an expert performer he has an immediate and intuitive experience of the possibilities afforded by the instruments. Such an acute and detailed experiential knowledge is to a large extent embodied, and rarely articulated. A challenge has therefore been to see how the subjective judgements relate to acoustic features in the sounds recorded from the instruments. This can be seen as a first step towards developing a more formal vocabulary for describing the instruments and their sonic and performance possibilities.

3. METHOD

This section reports on the methods used for recording, selecting and analysing sounds from a glass instrument.

3.1 Recording

Recordings were done in a controlled recording studio at the Norwegian Academy of Music. In concerts with the glass instruments, small DPA 4060 microphones have often been used because they are small and do not take up visual focus. However, for this study we chose to use a 'neutral' reference microphone, the B&K 4011. Three B&K microphones were connected to an RME mixtacy, and recordings were made in Samplitude using 24-bit resolution and 44.1 kHz sampling frequency. The microphone pre-amps were set to the same sound level (+40 dB gain), and no post-processing were done to the sounds.

Only one glass instrument was used in the study,[2] and it was placed on a stand in the middle of the recording studio, with microphones placed on stands around it. Placements of microphones and attack point were measured clockwise in degrees, with 0 degrees at the top of the bowl (Figure 2).

3.2 Excitation

For each microphone setup, three attacks were performed using a Premiere 689 short, hard yarn mallet. The mallet was selected based on the performer's experience of this mallet having a length and weight that would work well with the bowl.

[2]Referred to as bowl B in [4]

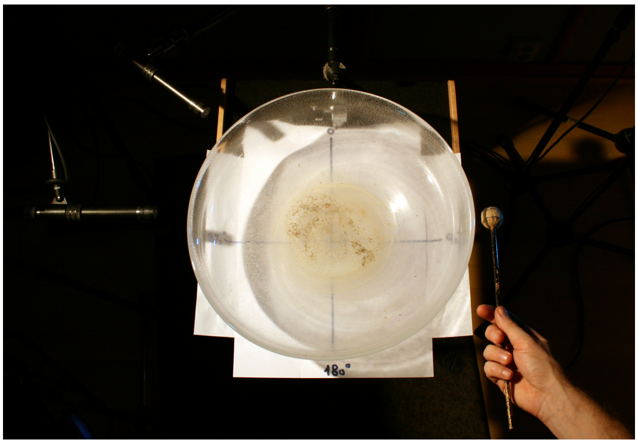

Figure 2: Setup of microphones placed at 270, 315 and 360 degrees, and excitation at 90 degrees.

Since our study is focused on the subjective experience of the performer, we did not want to use a mechanical/robotic system for excitation of the bowl. Rather, the performer tried to play attacks as he would do during regular practice, and with the aim of finding the best possible sounding result. This approach makes the study more realistic and artistically relevant, but also less objective. Since the attacks differ slightly, it is not possible to directly compare recordings from different attacks, but we are still able to compare the recordings for each of the three microphones for similar attacks.

Most of the attacks were done at the same position on the bowl, 90 degrees (see Figure 2), while microphone placements were changed. The angular position of the attack and microphone placements were noted for each take.

3.3 Selection

Sounds from the recording session were exported so that it was possible to listen to each sound from each attack from each microphone separately.[3] This resulted in 9 sound files for each of the 16 different microphone placements.

The first step in the selection process was to select the best of the three attacks for each microphone placement. This was done by the performer listening to each sample, and comparing the three attacks for each microphone position to each other. The evaluation was primarily based on listening at the *excitation* part of the sound, but also comparing the excitation to the *resonance* in the object [5]. This evaluation was done holistically, based on the general impression of the balance and sonic richness of the sound. The samples were sorted from 1 (best) to 3, and summed up to find the 'best.' An example of the judgement of Setup 5 is shown in Table 1, where the microphones were placed facing downwards at three positions 0.5 cm above the bowl (Figure 3). In this example, attack C was chosen as the best, with attack B as a good runner-up.

The next step in the selection process was to find the best microphone placement. Here the performer listened to all the 9 samples again, this time comparing the sonic result of the sounds based on the influence of the microphone placement. Again the samples were organised on a three point scale (1=best), and a winner selected based on summing up the values. An example of one such judgement is shown in Table 2. Here, sounds recorded at the rim were clearly judged as the best.

[3]See `http://www.nmh.no/nime` for a table with different sound recordings.

Table 1: Subjective judgement of attack quality for Setup 5 (1=best), columns represent attacks, rows represent microphone placement

	A	B	C
Rim	2	2	1
Half-centre	3	1	2
Centre	3	2	1
	8	5	**4**

Table 2: Subjective judgement of microphone placement for Setup 5 (1=best), columns represent attacks, rows represent microphone placement

	A	B	C	
Rim	1	1	1	**3**
Half-centre	2	2	2	6
Centre	3	3	3	9

The result of the selection process was a set of sounds with the best attack, and the best microphone placement for each of the 16 setups tested. It was these selected sounds that have been subject to further analysis.

4. ANALYSIS

The selected sounds were analysed qualitatively and quantitatively using Praat [1], and the MIR toolbox for Matlab [6]. The analysis mainly focuses on spectral features, since we believe the timbral differences between the sounds are more noticeable than many other features, e.g. pitch and dynamics.

4.1 Distance from the bowl

We started by evaluating the importance of the distance from microphone to the bowl. Here we assumed that a microphone placement closer to the microphone would reveal more of the attack, while placements further away would represent more of the sustained sound in the bowl. This was also what we found after testing various placements, ranging from 29 cm above the surface of the bowl to the surface level, and also below the surface level (i.e. inside the bowl). For our aimed target, namely further processing of the sounds, we found that the sounds recorded at 0.5 cm above the surface was judged the most interesting. Sounds recorded from microphone placements further above the surface (up to 29 cm) sounded more distant, while placing microphones under the rim gave a more dull sound.

4.2 Placement from above

The next step was to look at the horizontal positioning of the microphones. Figure 3 shows the microphone placement for Setup 5. Here the microphones were placed 0.5 cm above

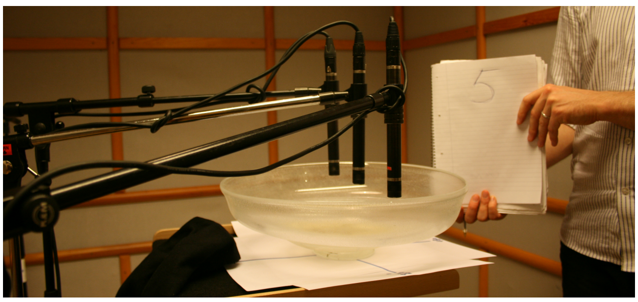

Figure 3: Microphone placement 0.5 cm above the surface, at rim, half-centre and centre positions.

the surface of the bowl at the following positions: rim, half-centre and centre. The subjective descriptions of the sounds by the performer were (1=best):

- Rim position (1): good balance in all registers
- Half-centre position (2): full low register, but less attack
- Centre position (3): bright but weaker

The immediate subjective evaluation, is that the sounds recorded at the centre position were considerably weaker than at the two other positions. This is also clearly visible in the spectra of the sounds (Figure 4), and when we calculate the root-mean-square energy of the sounds using the MIR toolbox (Table 3). While this is acoustically reasonable considering the bell-like shape of the instrument [2], we were surprised to find that the difference was so large, both qualitatively and quantitatively.

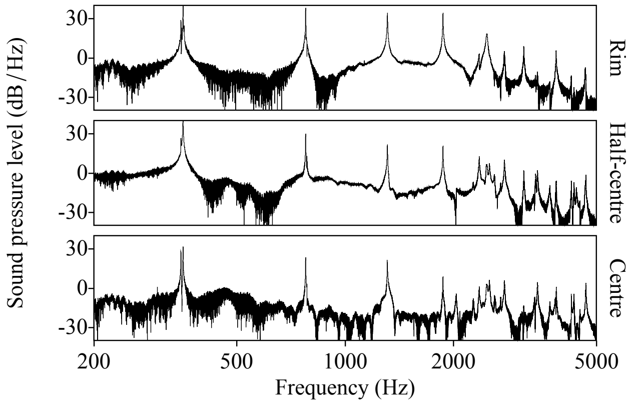

Figure 4: Recordings from above, with microphones placed at the centre, half-radius and at the rim.

Concerning spectral features, the spectra show that there are variations in the sound pressure level for the first formants of the sounds, with the first four partials being particularly strong for the recording at the rim, while the two other sounds have comparably high sound pressure levels between 2-5 kHz, a region where we are also particularly sensitive [3]. This is also shown in the numerical values in Table 3, where the spectral centroid, spread and rolloff indicate that the sound recorded in the centre is indeed much ‘brighter’ than at the rim. The spectral flatness values indicate that the sound recorded at the rim has a smoother and less spiky distribution than the others.

Table 3: Quantitative features of microphone placements for setup 5

	Rim	Half-centre	Centre
RMS energy	0.0049	0.0046	0.0012
Centroid (Hz)	2188	2539	3368
Spread (Hz)	33	51	79
Rolloff (Hz)	2533	3710	5896
Flatness	0.13	0.21	0.28

4.3 Sounds at the rim

After evaluating the horizontal and vertical placement of microphones above the bowl, and finding that the best results were obtained at the rim, we decided to look/listen at microphone placements around the rim in Setup 7. Figure 5 shows the placement of microphones equidistant from the rim, one on the inside, one on the top and one from the outside.

The subjective evaluation of these recordings were (1=best):

Figure 5: Microphone setup for recording sounds at the rim.

- Rim inside (3): strong, full
- Rim over (2): overtones in the attack, clear, bright
- Rim outside (1): overtones in the attack, more balanced

The spectra of the three sounds (Figure 6) show that the differences are small, but noticeable in the details, as can also be seen in Table 4. The sound at the outside of the rim was the weakest, but was also judged to be more balanced. The differences in numerical values are not pertinent, so it is difficult to draw a clear conclusion about the relationship between the subjective evaluation of the sound and its acoustic properties.

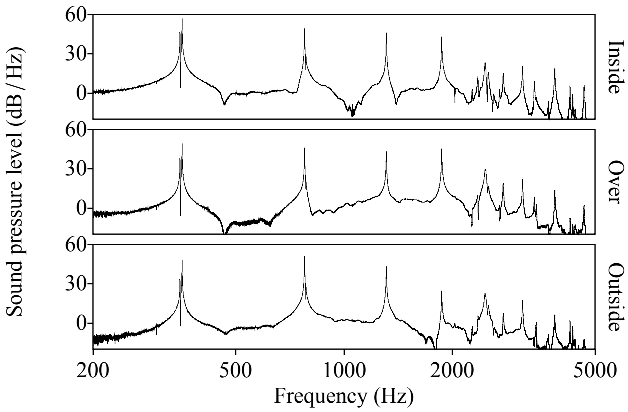

Figure 6: Recordings with microphones placed equidistant from the rim: inside, over, outside.

Table 4: Quantitative features of microphone placements for setup 7

	Inside	Over	Outside
RMS energy	0.017	0.013	0.011
Centroid (Hz)	1693	1991	1707
Spread (Hz)	9.2	9.1	12.7
Rolloff (Hz)	2552	2570	2528
Flatness	0.052	0.057	0.065

Generally, microphone placement outside the bowl was judged better than from above or the inside, but this was all for attacks performed from the outside. To check for the importance of the placement of the attack, we tested performing the attack at the same position (90 degrees) but from the inside of the bowl (Setup 16). In this case the sound recorded from the inside was judged as the 'richest,' and other recordings seem to indicate that the performer prefers sounds recorded from the same side of the bowl as he performed them.

Concerning the angular position of microphones as opposed to the attack, we tested different setups, with microphones placed horizontally towards the rim at angular positions 270, 315 and 360 degrees, and 270, 300, and 315 degrees, respectively. Here the placement at 270 degrees, i.e. 180 degrees from the attack were clearly preferred.

5. CONCLUSION

It is difficult to draw strong conclusions based on the fairly limited study presented in this paper. However, some tendencies seem to appear based on the subjective judgement of the sounds, and subsequent qualitative and quantitative analyses:

- Microphone placement closer to the instrument is clearly preferred over distant placement
- If recorded from above, better results are obtained at the rim
- There is a tendency that it is better to place microphones on the same side of the bowl as the attack (i.e. outside placement for outside attacks)

The most important finding from the study, though, was that the microphone placement close around the instrument matters much more than we originally thought. From a musical point of view we are happy to report that the fairly rigorous testing carried out has inspired the composition of new pieces and new performance techniques that take the obtained results into account.

Future studies will include looking at other types of excitation techniques, using different types of tools, and also test glass instruments with other shapes, sizes and surface structures.

6. ACKNOWLEDGMENTS

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