SUBJECTIVE EVALUATION OF ORGAN PIPE TIMBRE IN THE STANDARD LISTENER POSITIONS

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ABSTRACT

The paper deals with the dependency of tone timbre sensation in the real room on the listener's position relative to the individual organ pipes. Unlike the other musical instruments, in the case of organ three incommutable standard listener positions exist. These positions are closely associated with the subjective tone timbre evaluation of the individual pipe and the whole pipe sounding ensemble too.

The first one is the organmaker's position inside the instrument during the pipe voicing, the second one is the position of the playing organist by the console and the last one is the position of the listener in the church or concert hall auditory. The sound of single pipes (for different stops) was recorded in the positions mentioned above using artificial head, which simulates well the binaural sensation and the acoustic field deformation in the listener vicinity. The digital recording of a tone was carried out for additional two head turns. Afterwards the head was replaced by the pair of omnidirectional microphones and the whole recording procedure was repeated. Selected recorded tones were subjectively compared by listening in headphones.

1. INTRODUCTION

The pipe organ is without question the most complicated musical instrument from view of technical, architectonic and especially acoustical aspects. Concurrently the organ is made from the ensemble of the simplest musical sound sources – labial pipes with the exactly determinated pitch, loudness, timbre and place position in face of listener.

The organ sound, how we know it, for example in the form of plenum or tutti, is a "space" sum of particular pipe sounds. This sum is dependent not only on the quality of individual stops scaling and voicing, but also on the acoustical features of the room – church or concert hall. In contrast to other musical instrument the relationship between the organ and room is compact, changeless and unique, therefore all acoustic measurements and subjective evaluations must be realized "in situ" only. But the results of sound analysis as well as the tone timbre sensation are very different for each position of measurement microphone or listener in the church or hall.

Even thought several possibilities of statistical processing of data (for example the time or space averaging) exist, the influence of the distance between the one pipe and microphone or listener position is too high. The above listed three listener positions differentiate primarily just in this distance. The position of organmaker is very close to the tuned and voiced pipe with its only too concrete sound. Especially by the voicing the organmaker looks for an optimal position of his head, changes this position for another pipes by reason of good tone timbre sensation. Nevertheless he cannot correctly consider and discriminate the loudness and timbre tone proportion between two pipes or two stops, so he confronts very often his feeling with the sensation of his colleague sitting by the console or even in the room. The position of the organist is fixed (excepting moveable consoles), in this position he conceives the registration (selection of stops), the movement and whole performance conception of some musical piece. The sound of single pipes, stops and their combinations is well concrete, clear and balanced in this position too.

The basic sound quality evaluation of organs happens always by the console; the verdicts of organmaker and organist must by identical here. The position of the listener is very various and commensurates with the type, size and acoustical quality of the room (church or concert hall). The sound is less concrete and more spatial here; it highly reflects the acoustical properties of the room. We are often oblivious of the listener position by acoustical measurements of organ but this one is the most important and ultimate for the all in all review of organ sound, its character, quantity, quality, style, musical using etc. At last the listener position in the auditorium, especially its "sound quality" has quite concrete price too and with it connected positive or negative listener motivation.

2. EXPERIMENTS

The main goal of this work was the subjective evaluation of the listener position influence on the pipe tone timbre sensation. The evaluation was supplemented by the pipe tone analysis for each listener position. All experiments were realized on the organ of the Martinů Hall (Faculty of Music in Prague). This concert organ has 41 stops, 3 manuals and pedal with the mechanical action and was built by the Czech firm Rieger-Kloss in 1993 and re-voiced by the German firm Karl Schuke in 2002 (see Fig. 1).

The concert hall is approx. 25 m long, 10 m wide and 10 m high with the reverberation time up to 2.5 sec (160 Hz). The following stops of the 1. manual were chosen for the experiment: Burdon 16', Spitzgambe 8' and Octave 4' on the manual keys: B, e, b, e^1, b^1, e^2, b^2, e^3 and b^3, which represented the tones from B_1 to b^4. The artificial head Cortex C1/TO1 was used for the recording of analyzed tones, two omnidirectional microphones Brüel&Kjaer 4006 with the base 17.5 cm were used for the recording of subjectively evaluated tones. The tones with the duration 4 sec. were recorded and processed in format 44.1 kHz/32 bits by the software Cool Edit Pro 1.2.

Figure 1: *The organ in the Martinů Concert Hall.*

Figure 2: *The organmaker's position inside the organ.*

Fig. 2 shows the basic position of the head with the distance approx. 1 m from sounding pipes. The following two positions were the same but with the ± 45º turning round the head axis. Afterwards the microphones were located in the same three positions (related to the ears of the head). The next position of the head and microphones was situated near the console (see Fig. 3) in the distance approx. 7 m from the sounding pipes (with the same angular turning). The last position was in the auditory of the Martinů Hall in the distance approx. 17 m from the console (Fig. 4). In this position no turn was realized. In total 252 tones were recorded. Only the tones recorded by microphones were used for the subjective evaluation.

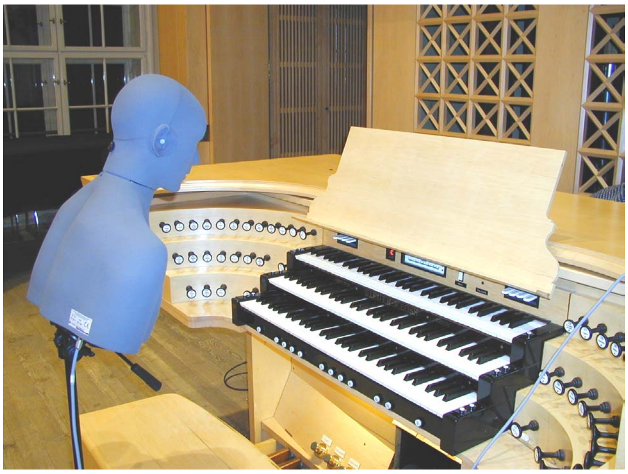

Figure 3: *The organist's position by the console.*

Figure 4: *The listener's position in the auditory.*

For the listening the open headphones Sennheiser HE 60 with the amplifier HEV 70 were used. The following tones were selected: On the keys B, e^1, b^2 for the stops: Burdon 16' (sounding B_1, e, b^1), Spitzgambe 8' (sounding B, e^1, b^2) and Octave 4' (sounding b, e^2, b^3). The position inside the organ was marked OM (basic middle orientation), OR (right turning), OL (left turning), the position of player by the console PM, PR, PL and only one position in the auditory AM (middle orientation). For tones with the same pitch the general sound dissimilarity in pairs was evaluated with the mark: from 0 (no dissimilarity) up to 5 (maximum dissimilarity) in the loudness, timbre, clarity of transient, noise presence etc.

The substantial simplification of the dissimilarity question comes out from the first view on this specific problem of the organ acoustic measurement and subjective evaluation. Therefore the first listening was restricted only on one person experienced in organ sound problems. On that account the following results have only the preliminary character and next data are currently processed.

3. RESULTS

Nine dissimilarity matrixes were obtained as a result of listening tests. The multidimensional scaling method (MDS), model with Euclidean distance was used for their evaluation (overview of models see in [1]). MDS model in general fits stimuli dissimilarities into distances of Euclidean space of appropriate low dimensionality.

In our experiment set of stimuli was represented by tones from the same stop and with the same pitch, and differing only with the recording position. Each set of stimuli includes seven tones: OM, OL, OR, PM, PL, PR, and AM. Two-dimensional solutions, which well reflect the dissimilarities in the most studied sets of tones, were used for the discussion of results.

For all evaluated stops and tones the organmaker's positions was clearly separated from the positions by the console and in the auditory. Dissimilarities were concerned first of all on the clarity of attack transient, timbre and loudness too. Substantially fewer differences were between the console and auditory position as a consequence of the relatively small volume of Martinů Hall. However in these cases the same dissimilarities were found as between the basic middle orientation and turning.

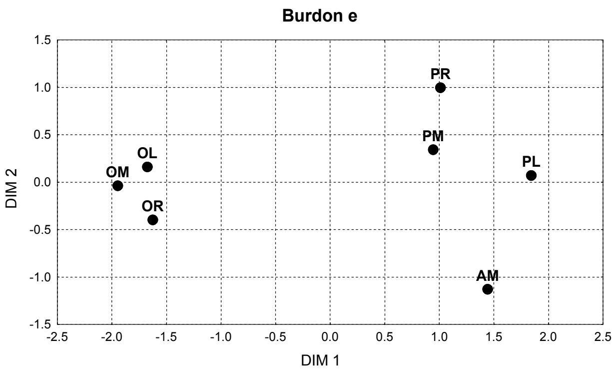

Figure 5: *MDS solution for Burdon 16',tone e.*

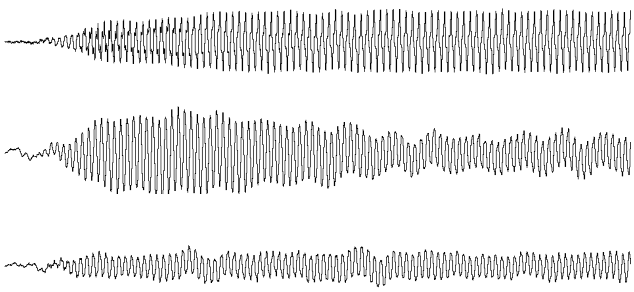

Figure 6: *Burdon – attack transient for positions OM-PM-AM*

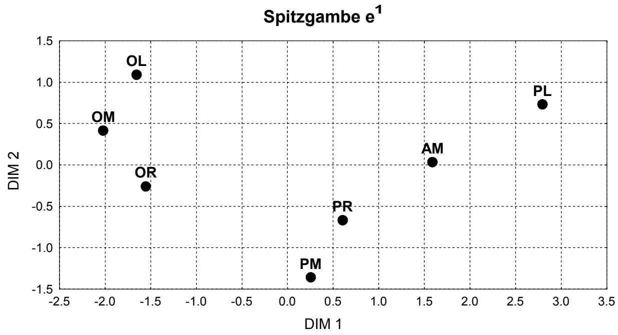

Figure 7: *MDS solution for Spitzgambe 8', tone e^1.*

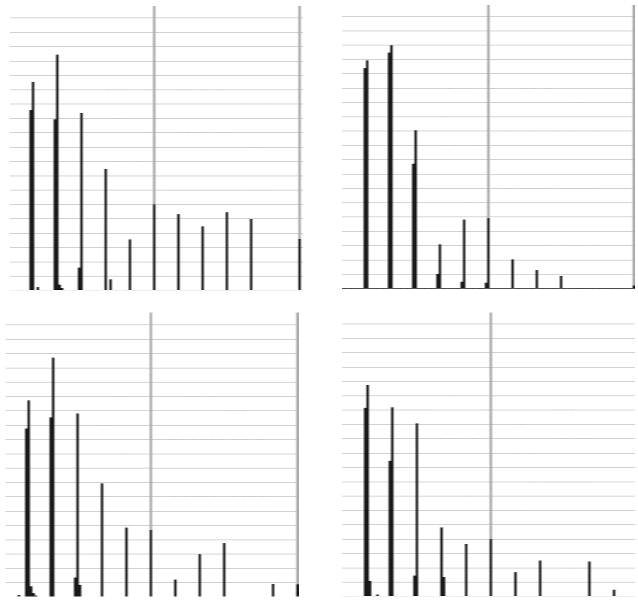

Figure 8: *Spitzgambe – spectrum for positions OM-AM-PM-PL*

Fig. 5, 7 and 9 show the dislocation of individual recording positions in the two-dimensional psychoacoustic space for given stops and tones. Fig. 6 demonstrates the attack transient differences for the „poor of timbre" stop Burdon 16'. Especially it's clear to see the characteristic chiff on the beginning of tone in OM position in contrast to PM and AM position. Spectrum differences for the „rich of timbre" stop Spitzgambe 8' are shown on the Fig. 8. In the upper part of this Figure are the spectra for the positions inside the organ and in the auditory, in the lower part is the interesting difference by the head turning in the console position. The last example on Fig. 10 shows the time envelope differences for the stop Octave 4', which hang together with an influence of the standing waves in the room.

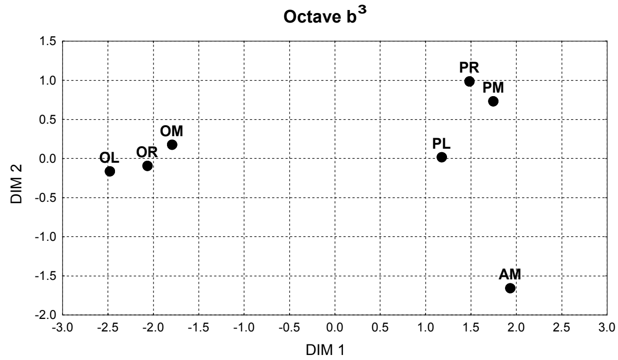

Figure 9: *MDS solution for Octave 4', tone b^3.*

Figure 10: *Octave – tone envelope for positions OM-PM-AM.*

4. CONCLUSION

The attained results (with all these only preliminary character) confirm the high objective and subjective dissimilarities of tone properties in the basic incommutable listener positions by the organ. The substantial differences were found for attack transient character and for the timbre of steady state too but in concrete case of Martinů Concert Hall in far less degree for the loudness of evaluated tones. These sound differences have a big influence by the voicing of single pipes or whole stops, by the organ music performance and evidently by the acoustic measurement. However the organ sound quality is evaluated first from the average listener position in auditory of the hall or church. One of many ways how to eliminate the influence of various listener positions is the averaging of measured data, other way is the simultaneous multi-track recording, subjective evaluation and following statistical processing of all data.

The continuation of this research will be focused on the separated processing of attack transient and timbre dissimilarity in the basic listener positions for more tones, another stops and on an organ in other hall or church. For listening tests will be used more qualified persons and more precisely specified questions about the object of the tone similarity or dissimilarity. This work is closely associated with the documentation method of acoustic properties of rare historical organs [2-6], developed and used in our Department of Musical Acoustics.

5. ACKNOWLEDGMENT

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6. REFERENCES

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