

The balance of the spectra of the tones of one organ stop

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Introduction

Experienced organ voicers are able to have concepts about sound quality of stops and about the balance of tone sounds within the stop in their mind and realize them accordingly. However, the evaluations, whether the stop tones are well balanced, are often complicate enough and also often ambiguous. What does the balance of sounds of tones of an organ stop mean? The definition does not exist, but we intuitively understand, that the tones, which appertain to one organ stop, are well balanced, if the perception of its sound does not change with tone height or, if the perception changes somehow fluently. Since the perceptions of sounds do not stay unchanged, when the pitch changes, it remains, that stop tones balance represents a fluent changes in sound.

Descriptions of percepts created by tone sounds need a psychoacoustic listening test. To evaluate auditive percepts, the psychoacoustics dimensions are usually used. In relation to organ sounds, two psychoacoustics dimensions are predetermined by music: *Duration* and *Pitch* (corresponds to tone length and tone height). *Loudness* of stop tones had to be proportional to the tones of other organ stop and had to be adequate to room acoustics. *Sound color* built up a stop character. Sound color (timbre) together with loudness (partly also predetermined by music) constitute the sense of pleasantness and yield to quality of tones. The definition of sound color implies that the sounds, which sound color the listeners can compare and evaluate, have to have equal pitch and loudness. In practice, when listeners judge the balance of stop tone sounds, they do not have a difficulty with evaluation of loudness but, they can not separate percepts of sound color from percept of the pitch. For instance the listeners can not answer, if the sound color stay constant, when the pitch changes. The reason, why it is hard to describe, what can change in the stop tone sound perceptions and, if this changes run fluently, is judgment of sound color.

Fluent changes in tone spectra

It is possible to use the harmonic spectra of tone sounds for detection of within a stop not well balanced tones, because tendencies in the spectra changes can be well visualized. Splain functions are applicable method for fitting of strains of harmonics. Afterwards the differences between sound pressure levels (SPL) of individual harmonic and splain function values can unfold not balanced tones. Organ sounds can not be measured in anechoic room, because the organs are inseparably joined with acoustic of its room. The measured spectra depend not only on properties of sound sources (organ pipes) but also on places of recording. The problem, where the organ spectra have to be measured, was solved in "Method of acoustic documentation of organ sound"[1]. Now this method is called *MARC 3+3* and in last

time was improved on *MARC 8+1*. In *MARC 8+1* documentation method, the single semitones are played. Sounds are recorded by 3 microphones above middle of usual listening places, by 2 dummy heads and by 1 microphone in an acoustic shadow (Figure 1.).



Figure 1: From left: 3 microphones above middle of usual listening places, dummy heads and microphone in an acoustic shadow.

Measurement and results

Presented harmonic spectra issue from measurement of Principal 8' stop of new organ (17 stops) in historical refectory in "House for Professed"(Faculty of Mathematics and Physics of Charles University in Prague).

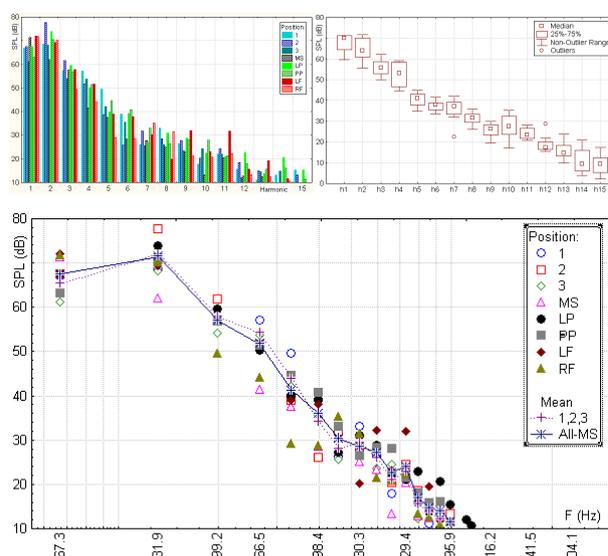


Figure 2: Example of measured harmonic spectra of tone C (C2) from 8 positions in the room: microphones in the middle (1, 2, 3), microphone in shadow (MS), left and right ears of heads at player place (LP, RP) and in the front of listening places (LF, RF). Top left: Bar graph of harmonic values; Top right: Basic statistical analysis of values; Bottom: Scatterplot of values and arithmetical averages.

An example of values of harmonic spectra and sound pressure (SP) averages is shown on Figure 2. Resulted SP arithmetical averages are again scaled in dB. Solid line on

bottom graph links averages of all positions without microphone in shadow; dashed line links averages of positions 1, 2, 3 used in *MARC 3+3* acoustic documentation method [1]). Data variability, presented on the tone C (C2 American notation), is typical for all stop tones and such organ measurement. Both, scatterings of values and also small differences between averages are similar to the shown example.

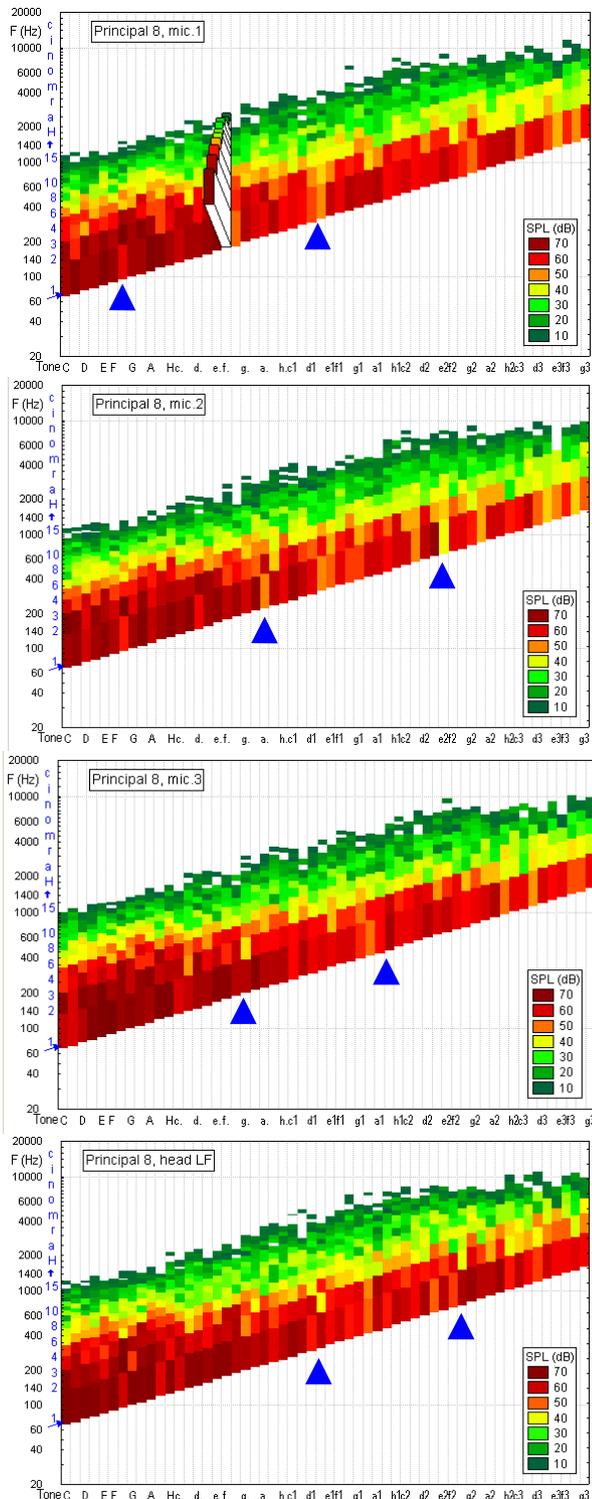


Figure 3: Harmonic spectra of all Principal 8' tones at once (From top: position 1, 2, 3 and LF; On top graph: the illustration of graph creation principle - top view on bars).

The harmonic spectra of all Principal 8' tones at once are presented on Figure 3 (positions 1, 2, 3 and LF). X-axis

depicted tone height of Principal 8' sounds from C to g3 (C2 to G6); Y-axis presents frequencies of harmonic (logarithmic scale) together with order numbers of harmonic (the number locations here are valid for tone C); SPL of harmonics are imprint by colors. Blue triangles mark examples (not all) of tones, which spectra are not well balanced. They often differ with position of recording. To reduce this room acoustic influence, the arithmetical averages of sound pressure values were calculated from microphone 1, 2 and 3 (as in method *MARC 3+3*). Remark: signals from dummy heads are used for listening test in *MARC 8+1* method. The resulted graph with average values of spectra is on Figure 4.

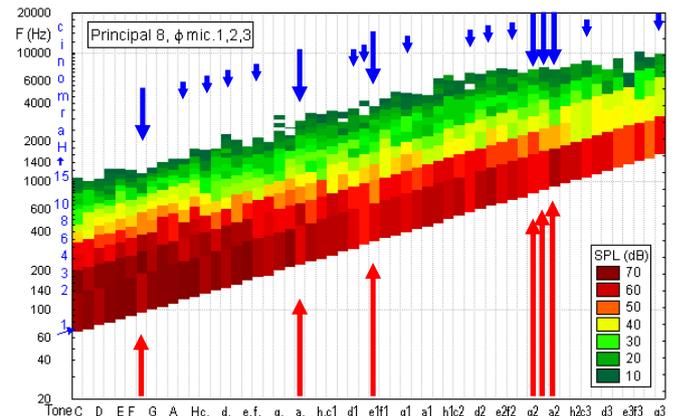


Figure 4: Averaged harmonic spectra of all Principal 8' tones (spectrum value averages from position 1, 2, and 3).

Discussion

The spectra on Figure 4 characterize primarily the acoustic properties of sound sources. Spectra differences of these tones arise mainly from an amiss voicing of pipes. Averaged data show lower number of out of tendency tones (long blue arrows in Figure 4). This finding corresponds to results of evaluation of measured new organ, evaluated by group of experts. Red arrows on Figure 4 mark those tones, on which should be revoiced the Principal 8' pipes (stated by the group of experts). Presented view on the stop tone spectra balance is helpful tool for unfolding of the tones, which sound is not well balanced.

Acknowledgements

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References

[1] Štěpánek, J, Otčenášek, Z & Syrový, V: Acoustic documentation of church organs. In proceedings of SMAC 93 (1993), 516-519