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From quantitative empirï to musical performology: Experience in performance measurements and analyses

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The term performology is introduced to describe the performer's "attempted control" of an acoustical instrument or a sound device. Four examples of performance analyses are discussed, three based on repeated MIDI recordings (Yamaha Disklavier grand and upright) and the last one based on repeated anechoic flute recordings.

Keywords: performance studies; music technology; methodology; acoustical measurements

The development of procedures and methodology for studying music performances has been heavily influenced by existing technology. Ortman (1929) made a lot of observations by visual inspection of piano players and developed a measuring device based on a mechanical pantograph.

New digital data technology including the MIDI data protocol has increased the possibilities to get reliable performance data in an easy way, far away from the qualitative opto-mechanical studies by Ortman. However, it is still a challenge to establish reliable data acquisition systems and procedures, define system precisions, and evaluate data reliability.

Repp (1999) has combined old and new techniques for the procedure of subjective evaluation and synthesizer simulations in the comparison of more than 100 recorded performances of the opening of Chopin's *Etude in E major* in an attempt to judge performance quality. One conclusion is "that very different patterns of timing and dynamics are aesthetically acceptable for the same music," which is in agreement with the statement in Tro (1998): "we may even have to accept a number of equally ranked families of phrasing patterns, or velocity contours, in the evaluation of performance quality."

The word "performology" has more or less become a standard term for the knowledge about—and the description of—the performer's activity during a performance. It may be preferable to limit the term to describe the "attempted control" of the instrument. This includes the overall or macro type of movement and behavior and at the same time all the micro type of muscle control and detailed fingering, intended or not.

In this sense, performology is for the musician what human computer interaction (HCI) is in the computer science world. We can call this field of research "musician instrument interaction" (MII) when we talk about standard acoustical instruments or "musician controller interaction" (MCI) when we consider general sound control devices.

Here, performology has so far been linked to a solo performance situation, i.e. one performer controlling one instrument. An intriguing broadening of the term could be the study of ensemble performances with several different instruments (symphony orchestra, big bands) or groups with several similar instruments (strings, brass, voices). Examples of performology research with solo piano and flute performances are shown below.

METHOD

Reported experiments are based on laboratory data from MIDI recordings and acoustical recordings with professional and semi-professional performers.

Procedure

All the presented piano analyses are based on MIDI recordings with calibrated equipments (Yamaha Disklavier Grand, CME/CRCA, San Diego, and Yamaha Disklavier Upright, model MX-100B, NTNU, Trondheim).

The first example is a simple dynamical control test. The ability to perform a slowly increasing crescendo by tapping one key repeatedly on the grand piano keyboard gives us an indication of the highest possible dynamical precision and sound level resolution in a piano performance as reported in Tro (2000). The performer was asked to play one crescendo from very soft to very loud by tapping the middle C on the keyboard repeatedly as many times as necessary. Then the performer was immediately asked to do one more performance. A third attempt was recorded too.

The second example is analyses of the dynamical contour of the eight starting tones of the Rondo movement from the *Sonata Pathetique* of Beethoven. The average dynamical contour of 20 recordings of one Norweg-

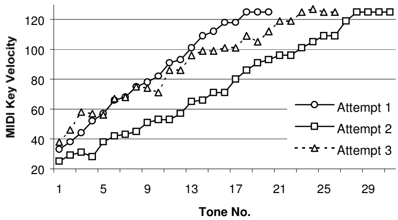

Figure 1. Crescendo performance with one key from three consecutive recordings.

ian semi-professional pianist is compared to the contour performed by Gerhard Oppitz in a professional Yamaha recording session 1988.

The third example concerns key attack precision in two consecutive chords (measures 16 and 17) in the previously mentioned Beethoven sonata. These two five-tone chords have been extracted from seven performances (one professional pianist) of the complete Rondo movement and analyzed.

The fourth example concerns key and blowing control in flute playing. Five versions of a flute concerto have been recorded as reported in Tro *et al.* (2003). One main question discussed is the actual precision for single tone onsets in staccato phrases, based on the fact that you have to control the key actions before the blowing tone transient starts in order to obtain the expected pitch.

RESULTS

Figure 1 shows single key crescendos. The dynamic steps vary from 1 to 10, measured in MIDI Key Velocity steps. The average step size was close to 3.

The different results of the three consecutive attempts may be explained by one psychological and physiological rehearsal-motivated effect (from attempt 1 to a better result in attempt 2), and one fatigue effect (from a superb performance in attempt 2 to a poorer controlled performance in attempt 3).

A second professional piano performer obtained a similar effect. Figure 2 shows the dynamical contour of the eight starting tones in the previous mentioned Beethoven composition. The upper curve is an average of 20 recordings of one Norwegian semi-professional performer. The lower curve shows the similar data for one professional Yamaha recording by Gerhard Oppitz, 1988. (The difference in absolute values is probably due to different mechanical adjustments of the two Disklavier used). Both contours in Figure

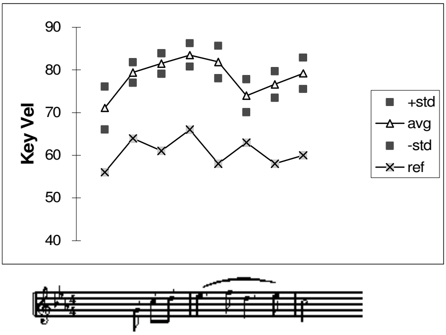

Figure 2. Comparison of performed dynamical contours.

2 sound musically acceptable and may be ranked equally in an aesthetical evaluation despite clearly significant differences.

Performance precision in piano chords is shown in Figure 3 (from Tro 1999). Two semi-ending five-tone chords (G major and C minor, measures 16 and 17, Beethoven sonata) have been extracted from seven recordings by one performer. We could expect all five tones to appear simultaneously for both chords. However, the analyses indicated that the two chords were performed with a significant different precision. The precision of the first chord did vary with no clear trend from take to take.

Figure 3 shows the key order of performer A's second chord. The MIDI Key numbers 36, 48, 72, 75, and 84 form a C minor chord. Here the order of keys, i.e. the order of performed tones, is remarkably constant with always the right hand "melodic" fifth finger (key 84) coming first and the left hand fifth finger's bass tone (key 36) always coming last. This may be explained as a fully controlled rapid arpeggio from high to low pitch in order to control the instrumental timbre.

Five versions of a flute concerto have been digitally recorded in an anechoic chamber (Tro, Bjerkvik, and Kristiansen 2003). One main question discussed is the actual precision and timing for single tone onsets in staccato phrases, based on the fact that you have to control the key actions before you start the blowing tone transient.

The repeatability in frequency was remarkable. Through ten identical phrases the single tone frequency was on average 740.2 Hz (SD 1.8 Hz). ISO pitch standard expects 740.0 Hz. A defined time delay τ_i (time distance from the start of the key action sound to the maximum amplitude of the following

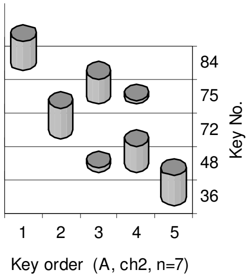

Figure 3. Key order of ending c minor chord.

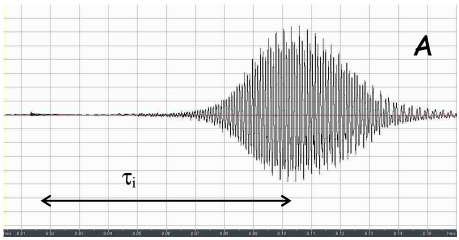

Figure 4. Staccato flute tone. τ_i indicates the time gap between key action and maximum tone amplitude.

tone) varied from 67-127 ms with an average of 94.5 ms (SD 18.0 ms). The duration of the staccato tones varied between 53 and 98 ms with an average of 78.8 ms (SD=11.8 ms). With a prescribed tempo of 132 bpm, the distance between eighth-note onsets should be 225 ms. Measured distance values from the analyzed tone to the next is on average 209.4 ms (SD=5.6 ms).

Spectral analyses indicate that the key action noise pre-excites the flute tube before the wind pressure produces the musical tone. The pre-excitation makes it easier to produce the correct pitch, as the expected partials are already present in the tube at a very low level.

CONCLUDING REMARKS

Data and computer technology has increased the possibility to get performance data in an easy way. It is still a challenge to establish reliable data acquisition systems and procedures, define system precisions, and evaluate data reliability.

In the evaluation of performance quality we may have to accept a number of equally ranked *families of phrasing and chord patterns* as aesthetically appreciated.

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