QUALITY ASSESSMENT OF MUSICAL INSTRUMENTS – EFFECTS OF MULTIMODALITY

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ABSTRACT

Background. A musical instrument is a device for producing musical tones. Therefore engineers traditionally associate the quality of the musical instrument with the quality of the tones it produces. In turn, the quality of the tone is determined by its acoustical parameters. In this deterministic logic, it is quite possible to judge the quality of the instrument by the parameters of its tones, provided the relations between them are known. From an engineering point of view the playing comfort and tone quality of a musical instrument are usually assigned to different design units of a musical instrument (e.g. key action vs. sound unit in pianos), For this reason, instrument designers like to have expert musicians' judgments of an instrument separated in acoustical and mechanical qualities.

Aims. We want to show, that this separation is not reliable under normal playing conditions due to psychological reasons. Practical ways of avoiding the problem are discussed.

Main contribution. Our experimental data suggest that the performer's impression of the quality of a musical instrument received simultaneously over the auditory and kinesthetic sensory channels are not additive. Cross-modal interference is a plausible explanation to why musicians confuse these impressions. Multimodal perception of a musical instrument by the performer and listener, respectively, is analyzed.

Implications. 1) Improving procedures of quality assessment in musical instrument industry; 2) Solving, on a psychological level, the classical controversy between musicians and physicists of touch dependence of a piano tone.

1. INTRODUCTION

From the point of view of engineers and physicists, a musical instrument is a tool for producing musical tones. Therefore engineers and natural scientists traditionally associate the quality of the musical instrument with the *quality of the tones it produces*. In turn, the quality of a particular tone is determined by its physical parameters – intensity, spectrum, duration, onset and decay transients, etc. In this deterministic logic, it looks scientifically attractive to judge the quality of the instrument by the parameters of its tones, provided the relations between subjective and objective characteristics of a tone are known.

Another important quality element of musical instruments is mechanical comfort, i.e. a *kinesthetic impression* as perceived by a performer, based on the mechanical feedback from the instrument.

The mechanical parameters and the tone parameters of a musical instrument, from a technological position, are usually assigned to different units of a musical instrument design, e.g. key action vs. string and soundboard ('sound unit') in pianos. Therefore for instrument designers it is important and desirable to have musicians/experts separate the mechanical and acoustical information when they assess the quality of a musical instrument in subjective tests.

From the performer's position, a musical instrument is an aid for expression of a musical idea, for producing an informative sound flow that best conveys a musical content, composer intentions, performer's emotions, etc. – much more than just an addition of single tones. A musician would reasonably say that a single tone signifies almost nothing for the music. As a rule subtle details of an individual tone (provided that the tone is not clearly defective) do not play a primary role in music production and perception, and consequently in the musician's estimation of the musical instrument quality via listening[1].

Moreover, (and this may make engineers upset), according to our experience of musical quality expertise in manufacturing applications it is impossible for a musician to judge the quality of a musical instrument reliably in pure listening tests, lacking information about how the tones were played. Here is one example clarifying this point.

2. EXPERTISE OF PIANOS

An experiment was organized at the Leningrad piano factory in the late 70´s (1, 2). At that time the factory received much criticism from musicians regarding the poor tone quality of the concert grand pianos made by our factory. Usually this poor quality was contrasted against the high (desired) quality tone of the Steinway concert grands from the Hamburg factory, the most popular piano among professionals in the Soviet Union.

The experience in subjective assessment of musical instrument tone quality in industry suggested that the quality was often estimated by a performer in free conditions quite differently compared to the strict "acoustically transparent opaque curtain" conditions. One example is presented in Fig. 1 showing the ratings of timbre and tone dynamics of four concert grand pianos (two *Leningrad-made*, one *Förster* and one *Steinway*). It is

[1] Piano voicers do that much better – they have an extensive and exclusive experience in listening, comparing, and correcting individual tones.

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evident that in the "curtain" conditions the quality differences between pianos became significantly smaller, and even the preferences had changed.

To resolve some reasonable doubts about the true design sources of the quality differences between pianos, we conducted a complicated three-step evaluation experiment, with 12 professional pianists as expert players/listeners. All pianists were pedagogues at the Leningrad Conservatory of Music.

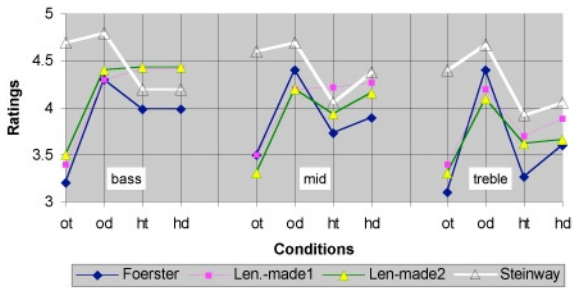

Figure 1. Rating of tone quality of 4 concert grand pianos in different conditions, averaged over 10 subjects. *CONDITIONS:* **ot** - open assessment of timbral quality; **od** - open assessment of sound dynamics quality; **ht** - curtain-hidden assessment of timbral quality; **hd** - curtain-hidden assessment of sound dynamics quality.

Step 1: Open estimation. Three concert grand pianos - Leningrad-made, Hamburg Steinway, and Bechstein were placed on the stage of the conservatory concert hall. The experts were asked to play whatever they wanted and to compare the three pianos (Fig. 2) in three pitch ranges (bass, middle, and treble) with respect to tone quality, dynamic range, and playing comfort. The experts were asked to fill out forms, using (a) free verbalizations of their impressions, and (b) to rate the pianos by their tone, mechanical, and overall qualities. The last question on the form was whether the expert thought that (s)he would be able to discriminate the instruments by their tone quality only, if presented to tones, chords or scales played on the pianos.

Figure 2: Free comparative estimation of pianos

The results of this open estimation were absolutely as expected. The tone of the Steinway piano was judged the best in all registers, followed by Bechstein, and the last was the Leningrad made piano. No clearly expressed comments were given about the differences in the key action. All experts found the differences in tone quality so distinct that they expected to be able to discriminate the instruments by listening to the played tones, chords and scales.

Step 2: Listening test. Listening tests with single tones, scales and chords played on the three pianos (from behind an acoustically transparent but optically isolating curtain) as stimuli were conducted. The listener's tasks were (a) to identify which of three pianos was played, or (b) to order two stimuli with respect to sound quality.

General result of this test was in short that the listeners appeared not able to determine properly what a piano of the three was played, and their preferences in ordering stimuli did not correspond to those expressed in step 1 of the experiment.

Step 3: Blindfold and kinesthetic tests. The three pianos were positioned on stage so that the keyboards formed a triangle. A rotating chair was placed in the middle of the triangle. The expert was blindfolded by soft eye covers before seated on the rotating chair (Fig. 3). The experimenter rotated the chair and stopped it in a position facing one of the pianos. The task of the subject was to play the piano and to identify which of the three pianos (s)he was playing. Following, a kinesthetic test was performed, in which the blindfolded expert was also "deafened" by headphones fed by white noise.

The result of the blindfold and kinesthetic tests were striking - almost all answers were correct. Even the subjects themselves were surprised by the results. For the experimenters - engineers and acousticians - this was quite meaningful: the results of the three steps of the experiment indicated that the quality difference between the three pianos, which was attributed by the experts in free conditions to the *tone quality*, was caused primarily by the *mechanical response*, thus dramatically re-focusing the industrial R&D from the tone generation unit (hammers, strings, and soundboard) to the key action.

3. DISCUSSION

The results of this experiment are easily explainable, taking into account that the perceived quality of a musical instrument is multimodal (Fig. 4). Let's consider the difference in the perception of a musical instrument by the performer and by a listener in a situation where they have to evaluate instrument quality.

The first evident advantage of the performer over the listener is that the performer can see the instrument played. (s)he is therefore informed about the instrument maker, age, how the instrument looks, etc. – and this is significant input to the performer's unconscious complex of preferences, prejudices, ideals and 'icons' that has developed by education and experience (3).

The second important advantage of the performer is that (s)he actively controls the instrument and perceives a very informative kinesthetic feedback. Simultaneously, (s)he receives an auditory

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Figure 3: Kinesthetic test. The first author prepares to rotate one of the subjects

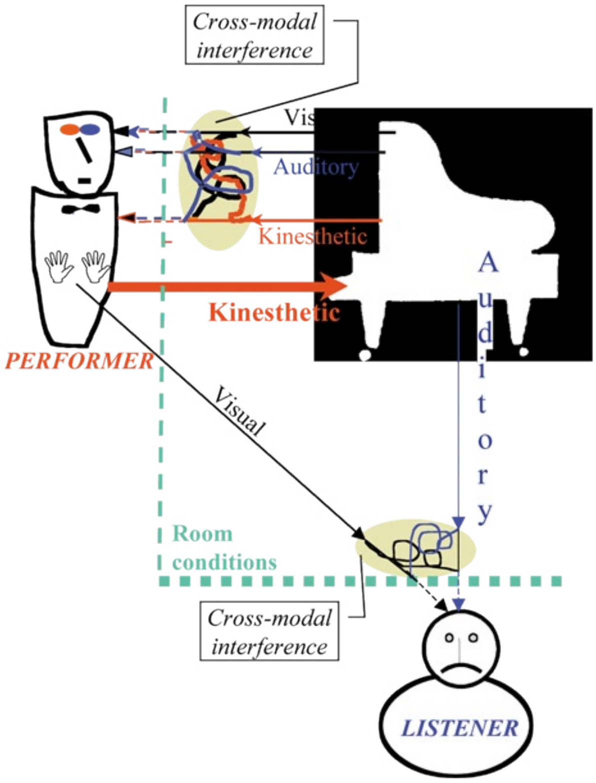

Figure 4. Musical instrument perception by performer and listener

response, the sound. Since both feedbacks are the result of the performer's own activity, (s)he has strong expectations and thus a better perception of the details of the feedback, which are not available for the listener.

A third important circumstance is that the performer and the listener are situated in different listening conditions relative to the instrument, and the acoustics of the room plays an important role. While the performer is well exposed to the direct sound from the instrument, the listener, being more distant, receives a more prominent proportion of early reflections from the room. Reverberation significantly modifies the sound flow to the listener (2), but not only that. Undesired room acoustic conditions (e.g. too much reverberation) forces the performer to accommodate to the room by correcting her kinesthetic interaction with the instrument (4-6), that, in turn, affects his (her) evaluation of the mechanical quality of the instrument.

In natural performance conditions, no unimodal impression of the instrument can be perceived in isolation from the impressions of other modalities (7). There are many evidences (including the results on the expert evaluation of piano quality described above) of an existence of a strong and valuable cross-modal interference between the visual, kinestetic, and auditory impressions of the instrument quality.

If the listeners can see the performer, the gestures and emotional behavior influence the listener's perception of the music (8-10) and consequently his (her) evaluation of the instrument sound.

Manufacturers of musical instruments and researchers have accumulated a considerable experience from subjective assessment of mechanical and acoustical qualities of musical instruments. Professional musicians are of course the best subjects for giving reliable and proper information about the quality of an instrument. With some subtle variations of details, two procedures are most used in practice: interviewing a playing musician (free conditions, full trust) or interviewing a listener.

Listening tests with the subject artificially separated from the instrument played behind an acoustically transparent visually opaque curtain are usually considered as giving the most "objective" quality estimates, excluding the influence of the listener´s prejudices.

However, even an elementary analysis of the psychological conditions, in which the listener is put by the experimenter, introduces great doubts about judgment reliability in these "strict" tests. In fact, the listener evaluates not the instrument alone, but a complex combination of the performer interacting with the instrument. Our experiences from quality comparisons between pianos suggests that in this situation the listener identifies a familiar performer easier than a familiar instrument. In experiments with cellos, it was reported [11], that the audible difference between a Guarneri 1657 and Testore 1740 disappeared when the mechanical playing device was replaced by a live musician, although the performer was instructed to play both instrument identically[2].

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4. CONCLUSIONS

Analysis of the industrial experience in quality assessment of musical instruments allows to conclude that:

- The overall quality of a musical instrument is a multimodal, non-additive combination of unimodal quality elements.
- The quality of a musical instrument is based mainly on the perceived correspondence between the kinesthetic and auditory feedbacks from the instrument in playing. Unconsciously the player evaluates the audio-kinesthetic discrepancy arising when comparing his (her) impressions of the instrument tested with her internal complex of educated ideals, preferences and expectations.
- The expert listener (even a high-class musician) is not a reliable expert of the musical instrument quality. The quality of a musical instrument might be evaluated reliably only by the performer.
- In engineering tasks, when it is necessary to evaluate the playing mechanism and the sound unit separately, it makes sense to isolate the expert from the instrument over the sensory channels that are not the main ones tested.
- Under such artificial conditions it is appropriate to use direct comparisons of instruments rather than absolute evaluations.
- The tasks for the expert musician should not exploit verbal scales and evaluations, but rather to be based on the recognition or identification of the instrument or simple preference scales – this helps to avoid individual terminological discrepancies between the experimenters and musicians.

5. ACKNOWLEDGMENTS

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6. REFERENCES

1. Galembo, A. (1982). Quality evaluation of musical instruments (in Russian). *Technitcheskaia Aesthetika*, *No. 5,* pp. 16-17.

2. Galembo, A. (1983). The problem of separate estimations of tonal and playing qualities of musical instruments (in Russian). *Proc. of the 10th USSR Acoustical Conference* (pp. 17-20), Moscow.

3. Galembo, A. (1987): *The quality of piano tones (in Russian)*. Moscow: Legprombytizdat.

4. Békésy G. von. (1933). Über die Hörsamkeit der ein- und Ausschwingvorgänge mit Berücksichtigung der Raumakustik. *Annalen der Physik*, *Band 16, No 7*, pp. 844-860.

5. Meyer J. (1977). Die Problematik der Qualitätsbestimmung bei Musikinstrumenten. *Instrumentenbau-Zeischrift, Heft 2*.

6. Simpson P. (1984). Determinants of the tonal quality of musical instruments. *Proc. of Acoustics'84 Spring Conf.*, Swansea.

7. Shinsuke Shimojo and Ladan Shams (2001). Sensory modalities are not separate modalities: Plasticity and interactions. *Current Opinion in Neurobiology, 11,* pp. 505–509.

8. Shimosako, H. & Oghushi K. (1996). Interaction between auditory and visual processing in impressional evaluation of a piano performance. *Journ. Acoust. Soc. Amer.*, *100(4) Pt.2*, p. 2779.

9. Hashimoto, T. and Hatano, S. (2001). Effect of factors other than sound to the perception of sound quality. *Proc. of 17th International Congress on Acoustics.* Rome.

10. Davidson, J. W. (1995). What does the visual information contained in music performances offer the observer? Some preliminary thoughts. In R. Steinberg (Ed.). *The Music Machine: Psychophysiology and Psychopathology of the Sense of Music.* Springer Verlag, pp.105-113.

11. Kern E., Glättli H. H. (1974). The Beziehung zwishen Musiker und Musikinstrument in sinnesphysiologischer Sicht. *HNO (Hals- Nasen-Ohren), 22,* pp. 297 – 308

[2] However, this doesn't mean that a mechanical player has to be preferred for such tests. The tone produced and the perceived differences are expected to be highly dependent on the parameters of the mechanical player, and how well they match to a particular instrument.

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