On Interface Expressivity: A Player-Based Study

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ABSTRACT

While many new interfaces for musical expression have been presented in the past, methods to evaluate these interfaces are rare. This paper presents a method and a study comparing the potential for musical expression of different string-instrument based musical interfaces. Cues for musical expression are defined based on results of research in musical expression and on methods for musical education in instrumental pedagogy. Interfaces are evaluated according to how well they are estimated to allow players making use of their existing technique for the creation of expressive music.

Keywords

Musical Expression, electronic bowed string instrument, evaluation of musical input devices, audio signal driven sound synthesis

1. INTRODUCTION

The Conference on New Interfaces for Musical Expression has presented a lot of challenging new interfaces in the past that can be used for musical performances. Regarding the question whether they are usable for musical expression, evaluation is often done by the developer or a small number of people. While the interfaces are frequently said to be highly usable, it often remains unclear which aspects of music and its expression the interfaces were designed for. A reason might be that evaluation methods are rare. According to the workshop proposal of NIME 01 [9] it is one of the goals of NIME to explore interfaces focusing on all aspects related to their potential for musical expression and to identify criteria for evaluating musical interfaces.

This paper presents a method to identify criteria for the evaluation of instrument-like controllers. The criteria include expressive cues found to be important in evaluating musical expressivity by research in music psychology. Indicators for a quantitative measurement are based on playing techniques known to be relevant for these cues. A measuring instrument is built to measure the player-estimation about the behaviour of instruments. Experimental studies and results are presented and discussed.

2. RELATED WORK

A lot of researchers address the topic of musical expression. Examples may be found in Jordà [4] or Blaine and Fels [1]. However, musical expression is one of the topics among others. A measuring instrument to evaluate the specific potential for expressive music of interfaces is not found. Wanderley and Orio present a method based on tools used in research on Human Computer Interaction (HCI) to evaluate interfaces [11]. It includes evaluation of learnability, explorability, feature controllability and timing controllabillity. Isaac uses these tools and modifications evaluating an accelerometer and a Korg Kaosspad KP 2 [3]. The evaluation method presented in this paper differs from previous work since measurement methodology is based on the expressive skills of musicians and the player-estimation of the interface-ability to deal with it.

3. MUSICAL EXPRESSION

Emotional expression plays a key role in musical expression [5]. Performers communicate musical expression to listeners by a process of coding. Listeners receive musical expression by decoding. Performers code expressive intentions using expressive-related cues (Brunswikian lens model, cited in [5]). Extensive work has been done to identify most relevant cues. These cues include: tempo, sound level, timing, intonation, articulation, timbre, vibrato, tone attacks, tone decays and pauses.

String instruments are known to be highly useful for musical expression. Performances with string instruments fall into the categories of music, explored by expressivity research [6]. The skills developed by string players offer the potential for the development of musically expressive string based interfaces. Where exactly can these skills be found? According to [2], instrumental playing techniques play a key role in enabling a string player to create musical expression.

There are, of course, a lot of other factors that may influence expression in musical performance especially when listener-evaluated. Juslin groups them into: piece-related, instrument-related, performer-related, listener-related and context related factors [6].
Important for the present research are:
- the factors that influence musical expression,
- the cues musicians use for coding expressive intentions
- and the methods string players use to create these cues with their instruments.

Interfaces built to use the expressive skills of string players will need to deal as well as possible with those methods.

4. EXPERIMENTAL STUDIES

According to present evaluation methods of musical interfaces the potential for musical expressivity can hardly be evaluated be-

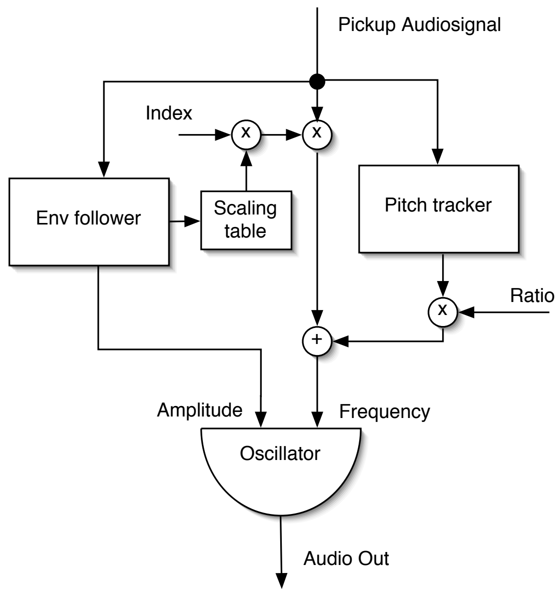

Figure 1: Flow Chart instrument C

cause the question of which kind of musical expression the interface will be used for cannot be answered [11]. Assuming an evaluation method that tests an interface by estimating whether it is usable to create a specific kind of musical expression, the assumption of Wanderley and Orio may be confirmed. However, if key techniques to create musical expression could be found, it might be a solution to estimate the interface according to these key techniques.

In this research it is assumed that playing techniques of string players related to the task of musical expression can be seen as a valid base to create musical expression. It is further assumed that playing technique is used to create expressive cues with the aim of coding expressive intention into sound.

The intention of the experiment lies in a comparison of the player estimated potential for musical expression of string instrument based electronic instruments for sound synthesis. Interfaces of these instruments are intended to use the mentioned specific skills of a string player for musical expression. Three instruments, based on three different structures concerning interface-mapping-synthesis are compared. The estimation of the players is measured by letting them evaluate whether the interface allows a player to create cues necessary for musical expression.

4.1 The Devices

The instruments are:
- Instrument A: ZETA Midi Viola-bridge mounted on a traditional viola, Midi-Synthesizer Kawai K5000, program A044.
- Instrument B: Electric viola, pitch and amplitude following, mapping, simple FM-Synthesis.
- Instrument C: The same electric viola, pitch and envelope following, mapping, ASDSS (Audio Signal Driven Sound Synthesis) [8] implemented with a modified FM-Synthesis (s. Figure 1).

Compared to traditional synthesis methods, ASDSS uses the audio signal of the interface as a control parameter. This parameter is the main controlling signal to drive the synthesized sound. This synthesized sound is indirectly shaped by control parameters like pitch or amplitude. A broader description of this method may be found in [8].

To compare the interfaces on the same base, simple FM-Synthesis is chosen. Leveling the problems of the ZETA System [7] in timing-accuracy, a synthesizer sound is chosen coming closer to the timbre of a string instrument than simple FM does. It may be expected that timbre accuracy will be higher valuated. Additionally, a traditional instrument-body is used to give the participant a hardware-feel closer to the original instrument. All instruments are given a similar small reverberation. To allow a better distinction between acoustic and electronic sound all instruments are transposed one octave down. Speakers (stereo) used are Adam P-11.

The envelope follower of instrument B and C is mapped to each carrier oscillator using the same tables. It is mapped using different tables to each modulation index. Synthesis is implemented in MaxMSP. The Max object *fiddle*∼ [10] is used for pitch and amplitude following.

ASDSS may be estimated to present nuances of sound variation applied by the player to the interface in the sound result even if they are not tracked by the pitch and envelope follower [8]. With respect to this assumption it is hypothesized that instrument C will be higher estimated than instrument B and A. According to the experience of the author it is hypothesized that instrument A would be estimated lower than instrument B and C. Since instrument A and B are driven by pitch and amplitude following it is hypothesized that instrument B will be valuated closer to A than to B.

4.2 Operationalization

In order to measure musical expressivity it has to be operationalized with a set of indicators. Existing research states a set of factors to be relevant [6] in performance of musical expression. While the present study focuses only on the instrument and the player, only following of those factors may be seen as relevant:
Performer-related:
- The performers technical skills
- The performers motor precision
- The performers emotion-expressive style
Instrument-related:
- Acoustic parameters available
- Instrument specific aspects of timbre, pitch, etc.

The mentioned instrument-related factors primarily need to be enabled by sound-synthesis. It is the task of the interface to bring performer-related factors via mapping to sound synthesis and (by doing this) adequately to sound. Focusing on the potential for musical expression it may be seen as relevant to measure whether players estimate the interface to be capable of doing this task.

According to operationalization, indicators have to lie in the field of the performer related skills and the estimated instrument response. The selected skills have to be relevant for the mentioned expressive cues (Section 3). These cues may be put into five interface-relevant cue-groups (Examples for playing techniques related to the groups are written in brackets):
1. Timing accuracy: tempo, timing, pauses (e.g. pizzicato, collé, spicatto, short notes)
2. Pitch accuracy: intonation, vibrato (e.g. different notes with pauses, legato tones, glissando, different vibratos)
3. Dynamics accuracy: sound level (e.g. crescendo, decrescendo, pp, mf, ff, sfz)
4. Articulation accuracy: articulation, tone attacks, tone decays (e.g. détaché, martelé, spicatto, scratching)
5. Timbre accuracy: timbre (e.g. go into the sound, pull the sound with the bow, change of bow-bridge distance)

Indicators to measure accuracy of the interface are the specific responses of the instrument to the related playing techniques.

4.3 Design of Experiment

Each test took about 90 minutes. 13 participants (trained string players) evaluated the instruments. Participants structure was: 7 women and 6 men, 8 professionals (earning their money with the instrument) and 5 amateur musicians. The musicians were members of professional orchestras of Cologne, Jazz-Violinists and amateur musicians. Participants were introduced to the experiment and tested each of the three instruments (20 min), they played and answered according to the questionnaire (60 min.) and they were interviewed (10 min.). The questionnaire gave 18 instructions to play specific musical tasks. Each task was followed by one of the three questions:

- Is the instrument transparent according to the playing method used?
- Is the relation gesture - electronic sound adequate?
- Is the intended sound result well represented in the perceived sound result?

The 18 tasks were related to playing techniques according to the five cue-groups (11 tasks), to scales performed with different articulation (2 tasks) and to musical phrases (5 tasks). The players had to play and compare all three instruments (changing order) with each task. A five point Likert-scale (1: not usable, 5: very good) was used. The participants evaluated each instrument with each task. When done with the 18 tasks, the questionnaire asked whether the participant considers the instrument as being usable for musical expression (in general) and as being usable for the personal musical expression. After finishing the questionnaire participants were interviewed on their experiences with the instruments.

5. RESULTS

Data from the questionnaires was analyzed by calculating arithmetic mean and median. It was analyzed whether personal factors like gender, amateur/professional and interest in electronic sounds matters in player estimation of the instruments.

5.1 Quantitative Results

According to the five point Likert-scale the overall values (mean) are: Instrument: A: 1,90; B: 3,59; C: 3,82 (Figure 2, see All participants). Analyzing different groups of people the following results (overall) were found: All results of the person-groups show the ranking-order of instrument A low, B higher and C highest (B and C much closer together than A and B). Analyzing in detail showed that participants with low interest in electronic sounds (8 participants) estimated the instruments B and C more different while participants with high interest in electronic sounds (5 participants) estimated instrument B very close to instrument C (Figure 2). Women and men did not estimate instrument C and B noteworthy different but women estimated instrument A higher in having potential for the creation of expressive music than men did.

Analyzing the cue-groups (section 4.2) the highest difference between estimation of instrument C and B was found in dynamics. Results of other cue groups, scales with different articulation and musical tasks are presented in Figure 3.

On the question whether the instrument is considered as being usable (in general) for musical expression 4 participants estimated instrument C most high, 2 participants estimated instrument B most high and 7 participants estimated both with the same value on the five point scale. Analyzing the 18 tasks of participants considering instrument B highest showed they consider instrument C on 3,5 (mean) tasks better than B. Analyzing participants considering instrument B higher showed they consider instrument B on 2 (mean) tasks better than C.

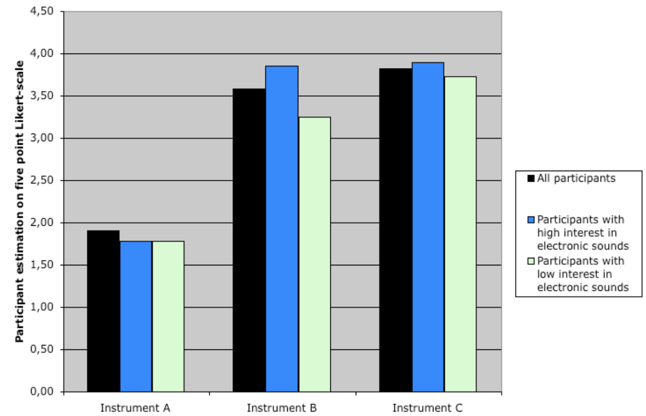

Figure 2: Player estimation on all 18 tasks (mean).

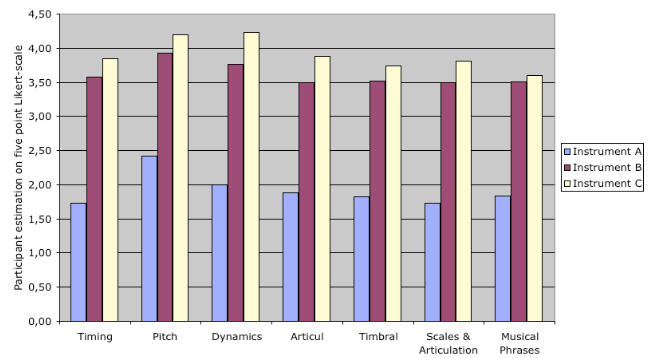

Figure 3: Player estimation on cue-groups, scales and musical phrases (mean).

5.2 Reliability and Validity

In order to examine the difference of the three instrument-estimations an analysis of variance (ANOVA) was done. A significant difference between the three was observed (F = 29.76, critical F = 3.26 and $p < 0.01$). Reliability within a cue group was examined by calculating the correlation of tasks asked twice. Correlation ranged between 0.40 - 0.74 (average 0.58). It may be concluded reliability of some tasks is low. The reasons may be seen in the modifications of tasks when asked the second time. Participants distinguished to a greater extent than expected between the different playing techniques belonging to one of the five cue-groups (section 4.2). Since reliability of some tasks is not high, the values presented in the graphs may be seen as tendencies but not as exact results.

To estimate validity the mean of data regarding all participants on all 18 tasks is compared with the mean of data found on the question whether the participants consider the instrument usable for musical expression (Table 1).

Table 1: Values to estimate validity

	18 tasks (mean)	considered expressivity (mean)
Instrument A	1,90	1,77
Instrument B	3,59	3,77
Instrument C	3,82	4,00

5.3 Interviews

Since participants ranked instrument B and C different (2 estimated B best, 4 estimated C best, 7 estimated equally) it was interesting to get comments on the reasons for their opinion. Concerning instrument B participants mentioned that it was more precise and better controllable in fast passages. Drawbacks of instrument B were seen in the cold sound and the poor response in slight tonally alterations. Mentioned reasons why instrument C was evaluated higher were: it feels more like a string instrument, it responds better to my input, I can play more warmly with it. A drawback mentioned on instrument C was the dirty timbre when playing ff. For both instruments it was often mentioned that they were to heavy and that the C- and G-strings had a different timbre than the D- and A-strings. Another drawback mentioned on both instruments was the bubbling sound by scratching or playing or noisy tone attack (pitch detection problems). A general conviction was, that if this disturbance could be disposed instruments would be much more usable. A request mentioned twice was to built a black box offering instrument B and C for stage use and without bubbling. In general instrument A was seen as very poor in response and only playable with extensive modification of playing technique.

6. CONCLUSION

While the result confirmed the hypothesized ranking, instrument B was much closer to C than expected. One of the reasons may be seen in the chosen implementation of ASDSS. The modified FM-Synthesis causes a strong tonal influence especially when played with a strong bow pressure close to the bridge. The resulting sound covers the ability of ASDSS to transmit nuances in sound not covered by the following system. A question might be why instrument C was estimated better in dynamics since B and C were using the same amplitude follower. Reasons may be found in the fact that timbre-dynamics play a big role in performing different dynamics. The instrument has to be capable of translating small variances in timbre-dynamics accurately to the sound. These small variances will cause a different sound output in instrument C because the audio signal with all its spectral qualities is directly connected to the carrier oscillator (Figure 1). Instrument B will correspond only to the predefined mapping of the amplitude follower to modulation index and amplitude.

In the presented experiment instruments are estimated using skills and techniques of an experienced string player. It may be expected that new instruments offer new possibilities. Observing the participants it was detected that some players try very soon to explore specific sounds like e.g. the bubbling sound when scratching. Some participants considered these sounds to be usable for specific expressive tasks. Since the test focuses on the skills already developed, such instrument-potentials are not represented in evaluation. However, it may be assumed that valid factors lie in the traditional playing techniques. Majority of the participants tested the instruments in the opening phase of each experiment with musical tasks of their repertoire trying to figure out the possibilities and limitations of the instruments.

The general method of evaluating controllers presented in this paper may be found to be useable for the estimation of new instrument-like interfaces. It allows considering specific expressive-related factors of the instrument more thoroughly. This paper has to leave out details of results due to limited space. However, the presented method shows a differentiated picture of the tested instruments which may be of interest for their developers.

7. OUTLOOK

It might be interesting to explore how musicians estimate the three instruments when tested for a longer period of time. It is known from synthesists that specific instruments, interfaces or sounds stay interesting over a long period of time while others do not. It also might be interesting to use the presented method to measure the player estimation on the expressive potential of other controllers. However this would have to assume that their concept on expressivity relates to expressive cues found in performance research and that playing techniques may be defined to create these cues. If the cues of existing research would not fit to their idea of musical expression, it would be interesting to know how this idea may be described and how it relates to existing research on musical expression.

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