Combining musical tasks and improvisation in evaluating novel Digital Musical Instruments

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Abstract. Digital Music Instruments (DMIs) have become popular in research labs and the physical computing community, and lately among performers of experimental music. Nevertheless, lacking the historical background enjoyed by acoustic instruments, it is difficult to compare and evaluate DMIs. In this paper, we detail a user study that aims to explore a unique DMI called the "Ballagumi" and to compare 2 distinct mappings designed for its interface. Our study benefits from the participants' musical expertise and qualitative analysis of verbal descriptions collected after replication tasks and improvisations to gain valuable insights on musical interactions with DMIs. The study also helps to demonstrate the role of mapping in musical interactions.

Keywords: Digital Music Instrument, user study, quality evaluation, mapping

1 Introduction

Digital Musical Instruments (DMIs) are composed of a physical interface, a sound synthesizer and an abstract mapping layer [1]. Although from a designer's perspective these 3 aspects may be considered independently, from a performers' perspective they overlap. Therefore, researchers aiming to evaluate a specific aspect of a DMI are often exposed to methodological issues. There is a continuous need to devise methods that can provide insight on the most important characteristics of DMIs from a performer's perspective. In this paper, we first discuss methods used in previous evaluation studies. Then, we propose and apply methods combining musical replication tasks and improvisation, both followed by interviews, in order to explore a novel DMI as a whole and to compare 2 distinct mappings. Finally, we report our observations from the experiment and the emerging results from analyzing the participants' feedback. The specificity of our approach remains in the experimental set-up, designed to be as close as possible to a real-life musical situation, and involving the participation of performers from the experimental music scene of Montreal.

2 Evaluating DMIs

2.1 Background

Methods to evaluate DMIs were first inspired by user studies, measures and models that have been developed in the field of Human Computer Interaction (HCI) and used to assess general interfaces [6][3]. Within the field of HCI, evaluation methods mostly focused on the achievement of tasks given criteria such as time and effort and were used to compare different input devices for office-based tasks. In a DMI however, the control interface only constitutes a single aspect of the instrument. As well, the usage of DMIs goes beyond task accomplishment and is more focused on fine control of interlinked, simultaneous, and time-dependent parameters to create musical effects through mapping and sound synthesis. Therefore, when evaluating DMIs, researchers also need to consider the mapping layer and the generated sound that largely influence the resulting musical interaction. In this view, Wanderley and Orio [3] stress the benefit of incorporating a musical context into the experiments that aim to assess the potential capabilities of a DMI such as its "learnability", "explorability", "feature controllability" and "timing controllability".

2.2 Incorporating a musical context

Given the lack of musical pedagogy on digital instruments, researchers need to design adapted musical tasks according to the characteristics of a DMI. Kiefer et al. used the proposed musical tasks by Wanderley and Orio [3] to evaluate the WiiMote as a musical instrument [8]. Butler [13] took this approach further by creating musical études that aim to enhance virtuosity in DMI performance. While these proposals emphasize the use of musical tasks, they do not discuss the participation of professional musicians for the task evaluation. Gurevich et al. [14] conducted improvisation sessions with musicians, which demonstrated the results of going beyond the reproduction of musical tasks and showed the creative possibilities of their novel instrument, though their choice of DMI was explicitly simplistic, which limited the scope of their findings. The participants in their study were music students but the authors did not specify whether or not they had expertise playing DMIs.

2.3 Quantitative or qualitative approach?

Stowell et al [9] discussed the impact of conducting solo and group sessions with experts such as beatboxers to evaluate DMIs. Authors argued that both quantitative and qualitative approaches could be appropriate to evaluate DMIs and should be selected depending on the desired outcomes. Quantitative methods allow researchers to measure interface responses and to analyze gesture accuracy using techniques such as Motion Capture [7]. Qualitative analyses allow researchers to investigate the performers' *perception* of the instrument. Two distinct schools exists in qualitative research: content analysis from Social Sciences

[15] and discourse analysis from Linguistics. Kiefer et al. acquired both quantitative and qualitative data in their evaluation of the Wiimote that allowed them to analyze gesture as well as performance feedback [8]. Cance et al. [12] and Stowell et al [9] discussed the benefit of using discourse analysis to evaluate DMIs. Specifically, Cance et al. collected verbal descriptions from both questionnaires and interviews, in order to investigate different perspectives among developers and performers of the Meta-Instrument regarding the notion of "instrumentality" [12].

3 Context of the Study

3.1 Objectives

This paper is based on a user study that is composed of 2 main objectives:

1. To explore how musicians express themselves with a DMI that they have never seen or played, minimizing possible personal bias.
2. To investigate the impact of mapping on the appraisal of a novel DMI.

To address these objectives, we designed 2 distinct mappings (see 3.3) for a DMI named "The Ballagumi" (see 3.2).

3.2 The Instrument - The Ballagumi

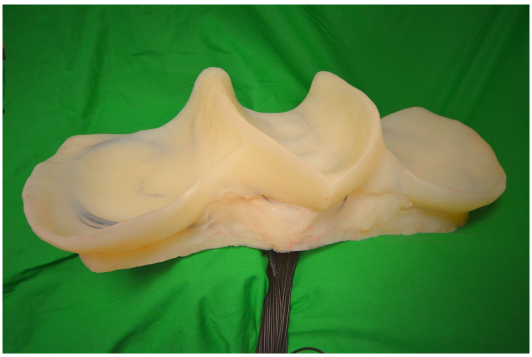

Fig. 1. The Ballagumi, by Avrum Hollinger

The Ballagumi is an alternative interface designed and built by Avrum Hollinger at the Input Devices and Music Interaction Laboratory - IDMIL. It "consists of a flexible physical interface cast in silicone"[11] with embedded optical fibres that act as bend or pressure sensors. The Ballagumi is composed of three sections: a central piece and 2 wings one on each side (see Fig. 1). The instrument is entirely malleable, however the thinner wings have a higher range of bending. Each embedded sensor generates a signal from the deformation of the silicone. These signals are sent to a mapping layer and then to the synthesizer. We chose this instrument since its shape and form do not resemble any known musical interface, thus it reduces elements of bias according to our first objective. Using silicone to construct the instrument is advantageous since it creates passive haptic feedback that allows "to generate resistance, leading to a more satisfying user experience" [16]. The elastic material "affords a continuous range of sensitivity" [16] and promotes new gestures to be performed such as twisting, stretching and squeezing. Such gestures have already been taken advantage of in other controllers or hyperinstruments, e.g. the Music Shapers [17], the SillyTone Squish Factory [16] or the Sonic Banana [18]. Since the Ballagumi does not have an inherent sound or predefined playing techniques, these gesture become a first step in defining its musical interactions.

3.3 Sound Synthesis and Mapping

The sound synthesizer chosen for this study is a modal synthesis patch with 2 frequency presets. This synthesizer is part of a series of tools created in Max/MSP for the McGill Digital Orchestra Project [19] . We used the Libmapper and the Mcgill Digital Orchestra Toolbox[19] to design 2 explicit mappings to be compared in the experiment, each using the same subset of Ballagumi's signals and the same output signals to the synthesizer. The conceptual difference between these 2 mappings is in the energy input required to generate and control sound. The 1st mapping is a direct-energy input mapping where sound generation and control are directly related to bending. The 2nd is a continuous-energy input mapping where sound generation and control are related to the velocity of bend in the middle ridge, requiring to constantly move the ridge. This 2nd mapping was inspired by Hunt's suggestion that "the incorporation of user energy presents a more engaging natural instrument, allowing the user to feel that they have connected with the instrument"[20].

4 Evaluation Method

4.1 Participants

We have invited 4 professional musicians (3 males and 1 female) from the experimental music scene of Montreal to participate to our study. They have an average of 16 years of musical experience (SD = 6). All 4 are improvisers. Three of them have performed with digital controllers on stage for an average of 10.5 years (SD = 7). Trained as a classical violinist, the 4th musician is a member of a contemporary string quartet specialized in expanded music practices, including the use of sensors and real-time electronics, though no experience with DMIs. This group of professionals with different musical expertise can bring different perspectives to inform our study.

4.2 Experimental procedure

The experiment was divided into 2 sessions corresponding to the 2 mappings. The order of tested mappings was counterbalanced among participants. The experiment took 2 hours in total, including a 15 minute break between the 2 sessions. Given their high level of expertise, the musicians received $80 for their participation. The experimental procedure is illustrated in Fig. 2.

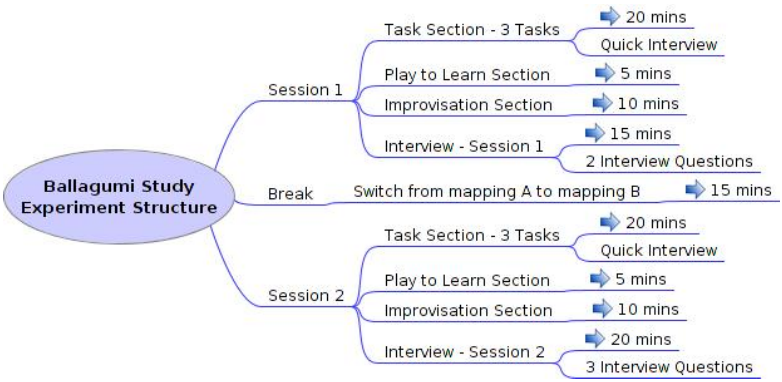

Fig. 2. The experimental procedure

In each session, the participant was first asked to reproduce 3 excerpts after listening to their audio recording (see 4.3) followed by a quick interview. They were then given 5 minutes to explore the instrument before being invited to improvise for approximately 10 minutes as if in a performance. The improvisation was followed by an interview. The replication task, improvisation and interviews were audio and videotaped [1].

4.3 Design of the replication task session

Several short pieces were composed by composer Beavan Flanagan, following the recommendations of Butler [13] who created muscial exercises for DMIs that test performers' technique while remaining musically meaningful. The pieces are at a technical level that does not require multiple hours of practice or extended techniques and can be played by both mappings. They are notated purely from the sound properties and do not suggest any gestures to the performer. We selected 6 recordings of the pieces[2] for each mapping[3]. In each session, 3 different recordings were randomly chosen and presented in a counterbalanced order to

[1] The 2nd author made the recordings using a stereo pair of high quality microphones (Schoeps MK21) that captured the sound from the speakers and the room acoustics.
[2] recorded by the 1st author as reference sounds
[3] 12 in total

the participant, each played as many times as the participant needed. A list of hints (presented below) was prepared to help the participant when she/he had a hard time reproducing the sound.

1. In general you need to use both hands to play the Ballagumi
2. Try moving your legs to get silence when not touching the instrument
3. Try playing with the middle of the instrument
4. Combinations of gestures work differently than individual ones
5. Try squeezing the ridges of the middle
6. Wings have a large range without the base. Try a lighter bend on the wing

4.4 Design of the interview guide

The questions of the interview guide were designed carefully to avoid influencing the participant's answer. With these questions, we discuss the main objectives of the study: The ability to explore and improvise on a new DMI, and the preferred choice of mapping. After the replication task of both sessions, we asked the participants *How would you describe your progression throughout the 3 tasks?*. After the improvisation, we asked the following: *How do you feel about the music you just created?*. and *How was your experience playing the instrument?* To evaluate the effect of the mapping change on the performer's experience, we slightly changed the questions of the 2nd session after the improvisation. They became *This time, how do you feel about the music you just created?* and *How would you compare your experience playing the instrument in this session versus the last session?* and lastly *Which set–up would you like to spend more time on in the future?* This last question also encourages the musician to present ideas about how to improve the mappings.

4.5 Analysis Method

The musicians' verbal descriptions collected during the interviews were analyzed qualitatively. Due to the exploratory nature of our study, a content analysis approach was preferred to a discourse analysis approach that would have been appropriate for specific aspects of the instrument [9]. We chose the constant comparison technique of Grounded theory [15] that allows to identify emergent concepts in verbal data, and then to classify these concepts into categories.

5 Results

5.1 Observations during Experiment

Each of the 4 participants used different gestures to create music, suggesting that the Ballagumi does not encourage a primary set of gestures. During the task replication session, participants needed the hints for 10 out of 12 tasks[4] for the

[4] 4 participants performing 3 tasks for each mapping

continuous-energy input mapping vs. 5 out of 12 tasks for the direct-energy input mapping, which suggests that a direct-energy input mapping is more intuitive at first than a continuous-energy input mapping. During the improvisation, all 4 participants preferred a minimalistic/subtle approach. Subtly in gestures were better controlled by the participants, though 2 out of 4 participants experimented with perscussive gestures to no avail because of the instrument's latency.

5.2 Analysis of the task replication feedback

Using content analysis by Grounded theory [15], we identified 4 main categories, namely *Instrument; Learning; Experimental procedure;* and *Mapping differences*. Regarding *Instrument*, besides commenting on the shape of the Ballagumi, participant 3 emphasized its symmetry; which suggests that mappings that take symmetry into account, contrary to the designed mappings, give a different initial impression. Regarding *Learning*, feedback were pretty consensual as they concerned the learning curve, i.e. 2 participants mentionned that there is faster learning at the beginning. However, details on the learning curve cannot be determined because of the short time nature of the study. A longitudinal study is required for this purpose. Regarding *Experimental procedure*, 2 out of 4 participants mentioned that having hints to guide the session is beneficial, both participants said this after playing the instrument with the continuous-energy input mapping, confirming our observation in 5.1. Regarding *Mapping differences*, all 4 participants confirmed noticing a mapping change during the 2nd session; 1 participant emphasized that being already familiar with one mapping impedes learning the second mapping right away.

5.3 Analysis of the interviews after the improvisation

From the interview results after the 2 experimental sessions, we identified 4 categories *Instrument and sound properties; Learning; Musical interaction;* and *Mapping differences*.

Regarding *Instrument and sound properties*, all 4 participants commented on the shape, weight and haptic features of the instrument, 2 participants discussed the existence of predefined sounds and 1 mentioned that the predefined sounds build a musical framework to improvise in. All 4 participants defined a gap between gesture and sound creation (latency), participant 3 specifically stated that this latency complicates the finding of intuitive links between gesture and sound. Regarding *Learning* as in section 5.2 the current results are consensual, leading to the need for a more extensive study.

When it comes to *Musical interaction*, several factors are repeated by participants: Gestures, Effort, Energy transfer from gesture to sound, and Improvisation styles. For Gestures, all 4 participants mentioned that slow and large gestures have a better sound. With respect to Effort, the female participant focused extensively on the effort required to play the instrument, and the 3 others mentioned that they felt the strain, especially with the continuous-energy input mapping, after playing longer. This is an important factor to consider in future designs of mappings for the Ballagumi: How do we modify mappings such that less effort could create the same sounding effects? As for energy transfer from Gesture to Sound, 2 out of 4 participants noted that the quality of gestures and the energy input are not always evident in the sounds, for example a fast move in gesture does not necessarily result in a fast movement in sound. This trend was dependent on the mapping, indeed, energy transfer was clearer with the direct-energy input mapping than with the continuous-energy input mapping. For Improvisation styles, 3 participants explicitly said that they preferred sustained sounds in their music and that they thus chose the direct-energy input mapping.

With regards to the *Mapping differences*, 3 out of 4 participants preferred the direct-energy input mapping. Participant 1 who preferred the continuous-energy input mapping mentioned that being able to obtain silence would change his preference. The main reasons behind the decisions were as follows: with direct-energy input it was easier to hit loud sounds, there was more control and participants could obtain sustained sounds, the mapping had a higher dynamic range and finally, it was more intuitive given the choice of interface. Two out of 4 participants mentioned that the direct-energy mapping was more dynamic and also that the transfer of gestural energy to sound was clearer; given that they were discovering gestures, this allowed more spontaneity than having to constantly move the instrument. This finding contrasts Hunt et al.'s suggestion that incorporating performer's energy would result in a more engaging instrument [20] but it emphasizes the design of the input device as a factor in the mapping design. Given that the input device's haptic features are alone interactive, and that the Ballagumi is elastic, holding a position for sustained sound requires energy as well. Therefore, both mappings demand performer energy, though in a different way. This may explain the contrast with Hunt et al.'s suggestion.

6 Discussion

Our observations and results provided us with insights about the Ballagumi and its 2 distinct mappings. Our experimental method allowed participants to focus on creating music rather than just accomplishing tasks, which in turn gave greater feedback in the interviews. For the Ballagumi, the observations suggest improving certain aspects of the instrument such as its weight and signal latency (this would also decrease fatigue from playing). Indeed, the additional difficulty in playing the instrument with the continuous energy input mapping is augmented by the latency. Improving the signal acquisition and parsing would in turn improve the overall playing experience. For the mapping, it was shown that both mappings require energy input but in different ways. It's the additional energy requirement by the continuous energy input mapping that makes the instrument less intuitive to play. The main idea to further explore is that for a DMI that is physically interactive, we may not need to explicitly add physicality to the mapping layer. Hunt et al.'s conclusion regarding physical involvement remains true but we need to explore up to which point the abstract mapping layer should add complication before the instrument becomes less intuitive (the case for the continuous-energy input mapping).

7 Conclusion and Future Work

The methodological approach presented in this paper could be adapted and applied to evaluate any technological device meant for musical expression. By involving professional musicians, tasks and improvisation, it contributes to bridge the gap between research and artistic performance. In the future, we will conduct further studies that focus on the learning aspect of the Ballagumi. Specifically, we plan to carry out a longitudinal study that spans over a few months and focuses on mastering playing techniques. We will also apply a few of the found suggestions to improve the instrument, namely the latency and weight.

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