Ecological considerations for participatory design of DMIs

A. Cavan Fyans, Adnan Marquez-Borbon, Paul Stapleton
Sonic Arts Research Centre
Queen's University Belfast
BT7 1NN, UK
{afyans01, amarquezborbon01, p.stapleton}@qub.ac.uk

Michael Gurevich
School of Music, Theatre & Dance
University of Michigan
1100 Baits Dr.
Ann Arbor, MI 48109-2085
mdgurev@umich.edu

ABSTRACT

A study is presented examining the participatory design of digital musical interactions. The study takes into consideration the entire ecology of digital musical interactions including the designer, performer and spectator. A new instrument is developed through iterative participatory design involving a group of performers. Across the study the evolution of creative practice and skill development in an emerging community of practice is examined and a spectator study addresses the cognition of performance and the perception of skill with the instrument. Observations are presented regarding the cognition of a novel interaction and evolving notions of skill. The design process of digital musical interactions is reflected on focusing on involvement of the spectator in design contexts.

Keywords

participatory design, DMIs, skill, cognition, spectator

1. INTRODUCTION

In the design of Digital Musical Interactions (DMIs) [10], instrumental skill is a prominent concern. The desire to create musical devices that facilitate long term development of advanced skill in performance is frequently discussed in NIME literature. Past studies of skill focused primarily on facets of the instrument and the performer-system relationship in the short-term [13]. While such studies consider performer feedback, only through longitudinal examination and response can we effectively develop and study rich relationships between designer, instrument and performer. It has been previously asserted that skill is a phenomenon that exists in multiple facets throughout the entire ecology of DMIs [5]. Not only in the performer system relationship but as a subjective judgement by spectators [5, 10]. Therefore, in designing skillful interactions, a holistic design approach considering the entire ecology of performance is necessary.

Originally proposed as a method of engaging workers as active stakeholders in the deign process of their own work systems, participatory design (PD) takes into account the requirements and needs of end-users to yield more usable and higher quality artifacts [2, 14, 16]. Through user involvement, it is possible to acquire knowledge regarding emergent usage patterns [16, 19] or, in the domain of DMIs, evaluate musical systems [1, 4, 9]. PD has been employed as a resource to examine and promote creative practice [17].

This paper presents a pilot study that employs PD in the development of a performance-ready [13] instrument to be used in a subsequent long-term study examining the emergence of skill within a community of performers. The PD approach employed is distinct in that group consensus, diversity of needs and existing practices of performers are accounted for. The emergence of skill within a group of performers is discussed in the context of the PD of an instrument supporting the development of skilled practice. Spectators are included in the last stage of the study and cognition, experience and judgment of performance with the instrument are examined. Observations are presented of the development, perception and judgement of performance across the entire ecology of performance, with reflection on implications for future design.

2. METHODOLOGY

2.1 Participatory Design

The study necessitated the use of a functional sketch instrument as a design prompt for the PD process. The sketch prioritised bodily movement and action over "office work" interactions [18] to leverage perceptual-motor skills and potential for skilled action [3, 12]. The use of a sketch in this context reflects the concept of a *design probe* [8] used as a provocation intended to "elicit inspirational responses" [7]. The Design probe further informed the PD in that tasks or goals were open (i.e. set individually by performers) and information was collected in a responsive way.

Following from previous studies that explored style and constraint in DMIs [11], a minimal, ambiguous interface was required so as not to prescribe a normative style of use [15]. This supported the examination of skill, allowing naturalistic development of skill amongst performers in the study. The sketch instrument (post-study named the Pulley-Synth [Figure 1], referred to as such from here on) consisted of a rectangular box (26x19x10cm) with a toggling power switch on one side and speaker grille on the top surface. Controls consisted of a spatial sensing system from a Gametrak game controller[1]. Its two analog joysticks were placed on the top surface of the instrument. Synthesis featured a fixed 200Hz tone, volume and harmonic content were controlled by the tethered vertical position sensors. The analog joystick controls were initially non-functional, limiting the sketch instrument to two degrees of control.

Four participants (henceforth referred to as performers) volunteered for the study: one undergraduate music student and three professional musicians. Two had experience in designing and performing with DMIs. The remaining two were experienced acoustic instrumentalists with basic expe-

[1] `http://goo.gl/WTODO`

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rience of DMIs. The study had a duration of three months, concluding in a public concert, and was divided into three iterative periods of one month. The first two weeks of each iteration consisted of individual practice followed by a two week instrument redesign.

Each participant received a copy of the instrument and a practice logbook. Instructions were to practice and document their experiences with the device. No instructions regarding techniques or technical function were given, allowing for a naturalistic research context. At the end of each practice period, designer-led interviews were conducted individually and in focus groups. In focus groups, performers demonstrated instrumental abilities and discussed experiences in open and directed discussions. Performers were also directed to discuss and propose changes to the design.

Data collection included a questionnaire regarding previous training and experience, as well as an exit questionnaire used to reflectively report the performers' experience across the study. Practice logbooks documented performer's individual practice. Interviews, focus groups and the final performances were video recorded for analysis.

2.2 Spectator Experience

To study the spectators' experience of the Pulley-Synth, data was collected from spectators at the final performance using a post-performance questionnaire based on previous studies examining the spectator experience [6, 5, 10].

Twelve participants (henceforth referred to as spectators) were selected from the attendees of the final performance. The performance was publicly advertised and ecologically situated in a hall under typical concert conditions. Spectators were aware that they were participating in a study.

Following the performances, spectators completed a questionnaire covering aspects of their knowledge, perception, understanding of the instrument and their judgement of performance. This paper focuses primarily on responses regarding the understanding of the performative interaction and the skill of each performer. Questions combined qualitative and quantitative responses, primarily free-response descriptions and numerical ratings.

The data collected from both the performers and spectators was transcribed, coded and analysed post-study. Qualitative Data Analysis was used to explore emergent themes.

3. PD & PERFORMER DEVELOPMENT

3.1 Initial Experiences

A week after receiving the instrument, individual interviews were conducted with the performers. Initial reactions centered on the instrument's novelty and performers' unfamiliarity with the interaction. Attempts to relate the novel interaction to familiar experiences were made in order to understand it. Comparisons of the Pulley-Synth with the Theremin were often made based on the perceived similarity in their manual gestures.

Performers reported quickly learning the primary interaction; pulling the strings of the tethered position sensor. During this period, performers explored different ways of playing focusing on the development of physical skill as expressed by notions of *control* and *repeatability*. They also described actively developing knowledge and understanding of both sonic and functional capacities of the instrument.

For some, the perceived simple design of the instrument was a constraint. As one performer expressed, "I found I had exhausted its possibilities. I felt the sonic possibilities were very limited." In one case, the lack of sonic diversity resulted in a reduced engagement in practice. Despite perceiving to have reached the ceiling of instrumental possibilities, this

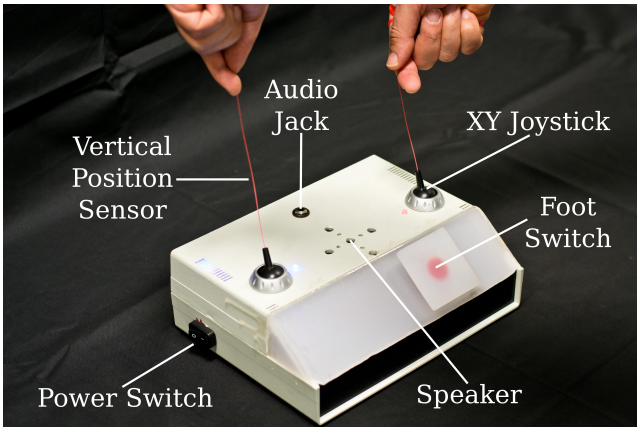

Figure 1: Pulley-synth final version

performer did not report being a *master* yet. For others, the perceived simplicity was a positive attribute, motivating further refinement of skills and enhancement of their creative output within the constraints.

3.2 Focus Group 1

After two weeks of individual development, the first focus group involved a show and tell exercise consisting of a brief performance and explanation of individual approaches and experiences with the instrument.

The first performer, driven by the perceived physicality of the instrument, sought to develop a repertoire of large whole-body gestures to be utilised through improvisation. The second performer motivated by the instrument's timbre, described as reminiscent of "folk vocals," developed a performance emulating that style. He was alone in developing a wah-wah modulation technique by cupping his foot over the speaker. The third performer expressed having reached "what was possible" sonically, due to the instrumental constraints. He felt no incentive to continue practicing and reported his performance "worsened" due to lack of practice. The fourth performer, contrasting the group, did not like the large gestures afforded by the instrument and consequently developed independent manual control of smaller gestures and producing repeatable melodies.

This focus group revealed that the performers developed distinct performance styles based on different initial impressions and interests. For several, exposure to different techniques and performance approaches resulted in desires to imitate or incorporate new techniques in their practice.

At this point performers were asked to assess their own skill level on the Pulley-Synth on a five-point scale. Performers ratings ranged between 2 and 3.5. Judgments were based on a perceived improvement of physical skill (control & repeatability); quality of musical performance; and amount of practice. Interestingly, skill assessments were adjusted based on new conditions after seeing the other performances. The observance of novel varied techniques revealed their own practice covered less of the instrument's possibilities than they thought. One performer keenly commented on the contextual nature of skill, predicated on the ability to situate his performance in a community of practice, "Before I came here I would have definitely said 5 out of 5. But I suppose rating your skill is contextually aware. You can't really say if you're a novice or a pro unless you can compare your performance with someone else's." It was observed that performers had difficulty assessing their skill at this stage, notably due to the limited exposure of other praxis.

Finally, the focus group centred on the design of the

Pulley-Synth. Performers were prompted to suggest and discuss modifications to the instrument. Limitations of the instrument's fixed pitch were a primary concern for all performers. However, the implemented change divided performers decisions. One performer noted, "I just want it gliss' so I can pick whatever pitch." Others proposed maintaining the fixed pitch but adding effects (delay, reverb or ring-modulation) for greater timbral variety. Reaching a group agreement proved difficult resulting in an ambiguous desire for more control parameters, variable frequency and greater timbral range. The implemented improvements included increasing the volume; a discrete foot-switch for note triggering; an external audio jack; reducing string length; visual feedback; and a change to the synthesis engine, producing a single sine tone with linear frequency and volume control. Other improvements were rejected by the designer due to feasibility or lack of consensus between performers.

3.3 Focus Group 2

After the redesign, performers spent another two weeks practicing with the updated instrument before the second focus group. Several issues regarding the design were raised at this point. Initially performers perceived the modifications, although reflecting their desires, to be disruptive to creative practice. For some, this issue resulted in adapting established techniques to fit the new design, albeit with difficulty, "I was trying to create some kind of rhythmic thing using the volume string. I tried to do that today but I couldn't." Similarly, the large physical gestures were somewhat lost due to the added foot-switch, fixing performers to one spot. One performer noted, "You have to have a constant point of contact, before you could move around, but now you can't move far away and do things."

Technical issues with the new synthesis engine compounded these problems: The linear frequency control introduced a control delay; the volume control provided a limited dynamic range. One performer expressed his frustration, "The volume control doesn't really do anything anymore and notes are not as responsive." While the redesign was perceived as restrictive, performers developed approaches to cope with the constraints. Some accepted the constraints, adapting to them as one noted, "You just have to devote some time to it, try to master whatever you can." Others subverted the constraints by using the new external output, incorporating the Pulley-Synth into existing performance systems (computers, effect pedals) making the instrument more "usable".

In this focus group, performers assessed the skill of the other performers. This proved difficult due to the diversity of styles. Skill could not be based on a generalised set of criteria or attributes for the performances. Instead, the basis for skill assessments was adapted for individual performance practices and goals. One performer remarked, "It's kind of hard to say that somebody is successful in one approach. It doesn't necessarily mean they would be successful in a different approach." Despite showing difficulty in forming a basis for judging the skill of others, performers displayed an intrinsic embodied understanding of the instruments' function and possibilities through adapting their notions of skill to assess the diverse performance idiosyncrasies and goals.

The second design discussion focused on issues from the first redesign. As a development, performers were encouraged to brainstorm and propose ideas through drawings and physical sketching. For the performers, these methods provided better insight into the proposed modifications. Subsequently, the foot-switch was changed to mute rather than to activate and a new synthesis engine was suggested to fix the control delay. Careful deliberation by performers resulted in the implementation of a combination of FM synthesis and bandpass filter, fulfilling desires for greater complexity, variety of timbre and more control parameters.

3.4 Final Performance

Two weeks after receiving the final version of the Pulley-Synth, a public performance[2] concluded the PD. In the performances, previously observed individual styles in creative practice were displayed, despite the development of shared performance practice. Performers also made a final self-assessment of skill after the performances. Following previous observations, perceptions of skill were based on the achievement of individual goals. Ratings were considerably higher than previously given, ranging between 3.5 and 4.

4. SPECTATOR EXPERIENCE

Observations from the spectator experience study revealed varied factors influencing the spectators' perception of the instrument and judgements of performer skill, reflecting observations from previous studies [5, 10].

Many spectators' skill judgements focused on performers' physical skill: degree of control (having "a lot of control of the instrument" or "more sensitive" control); and diversity of technique. Intellectual skill, the perception of conceptual understanding of the instrument's functions, was also salient in spectators' judgments. One performer displaying, "A great understanding of how to control the interaction of the two oscillators, the specific manipulations available to produce specific sounds", was deemed highly skilled.

Skill judgements were also influenced by perceptions of embodied knowledge of the instrument, an intrinsic performer-instrument connection. Or, as some noted, opposing perceptions of disembodied cognition [5]. Observed in statements regarding performer confidence and physical comportment, one spectator noted, "The lack of eye contact away from the instrument indicates a lack of skill." For others, skill was manifest in confidence, perceived through "passion", "comfort" and "playing by instinct".

Despite clearly defined attributes, skill judgements were ambiguous due to lack of experience or knowledge of Pulley-Synth performance practices, or exemplars, with which to situate performer's skill. One spectator clearly noted, "I'm not sure. I would have to see somebody play it for years to compare." Difficulty also resulted from lack of experience of the interaction or its performative context. Spectators couldn't judge skill because they were, "Not familiar with the instrument" or didn't know how the instrument *should* be played. Others expressed, "Struggling with understanding correct and incorrect ways of playing it."

Spectators were however in agreement that the instrument was controlled by, "Pulling the strings in different directions". Although their understanding of the performative interaction was often inaccurate. Descriptions varied from precise (but inaccurate) technical explanations to gestural descriptions, such as the instrument being operated by radio waves. Lacking a clear understanding of the translation from gesture to sound or expectation of *normative* practice created difficulties in meaningful assessment of skill.

5. DISCUSSION

The Pulley-Synth supported development of diverse performance approaches, informed by individual perceptions, goals and creative practices. However, the diversity posed a challenge in the PD process. This is attributed to key differences in the design of DMIs and the original HCI context of PD; creative practice with a musical interaction is an inherently open-ended process. In the performance of DMIs

[2] `http://goo.gl/ImUoB`

the *goal* is not the most efficient execution of a task, but the realisation of subjectively defined goals. These range from symbolic and easy to specify, to realising abstract concepts. Even within this small group of performers and short period of time diverse goals were seen, driven by equally diverse motivations, expectations and desires from the instrument. Subsequently, divergent ideas were presented by performers for each redesign. Thus creating problems in applying the *best* or most desirable instrument revision.

Further to the distinction of goals or tasks, in creative practice with DMIs, goals are inherent within the activity itself. This became clear as instrument redesigns frequently disrupted individual practices. Often due to variance not only altering the performers' ability to achieve goals but shifting their conceptual model of the instrument, but altering expectations of the instrument's possibilities, constraints and purpose. As the goal is inherent in the action of performance, changing the interaction resulted in a change in activities *and* goals. Even when presented with desired modifications, they were disruptive to individual skill development and creative practice. This was a product of mental models of the instrument or models of conceptual expectations not fitting the redesigned system. In applying PD to DMIs, designers must be vigilant of the inherent diversity and individuality of goals and creative practices generated by instrumental constraints and stylistic diversity [11].

The performers' understanding of skill with the Pulley-Synth evolved throughout the study. Judgements were initially ambiguous and gained more meaning as their actions were defined within the group. Assessments, practice and goals gradually consolidated and gained meaning through the influence of their peers. The absent knowledge of performance practices within a community of practice, or prior exemplars in which to situate their activity, made assessments difficult [5, 10]. By the final performance the budding community of practice afforded the performers a deeper understanding of skilled practice. They were able to form meaningful judgements of of both their own and observed performances, despite the presence of distinct styles.

Spectators, however, were unable to make confident or accurate judgements of skill despite viewing four performances of the same instrument. This was based in part on two key factors: understanding of the performative interaction and knowledge, or experience, of a community of practice. Spectators' relied on inaccurate mental models of the interaction to inform judgements (e.g. the instrument being controlled by radio waves). This produced inaccuracies in understanding the relationship between performers' intentions, actions and resulting performance, making the interaction opaque and hard to derive meaning or form judgement.

It is salient to note that the designer and performers perceived the Pulley-Synth's interactions to be relatively simple and easy to understand. Yet the spectators had difficulty understanding and judging the interaction, attributed in part to their knowledge of DMIs and experience of a community of practice. Spectators' inability to assess skill reflected observations of performers' judgements in the early stages of their development. Without the knowledge of exemplars or an understanding of *expected* practice, judging performances becomes difficult. This phenomenon was observed even in *expert* spectators, reiterating traits from previous studies [6]. Designing DMIs through an iterative, PD-based approach that includes spectator feedback would support addressing issues of spectator understanding. However, without the influence of experience of a community of practice, judgements are still difficult. Fostering a community of practice for an instrument or leveraging facets of an existing community may generate a knowledge base required to support the understanding of a skilled interactions. Although the spectator still requires experience of them. Given these observations, it is predominant for the design process to account for the entire ecology of performance.

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