Designing Digital Musical Interactions in Experimental Contexts

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ABSTRACT

As NIME's focus has expanded beyond the design reports which were pervasive in the early days to include studies and experiments involving music control devices, we report on a particular area of activity that has been overlooked: designs of music devices in experimental contexts. We demonstrate this is distinct from designing for artistic performances, with a unique set of novel challenges. A survey of methodological approaches to experiments in NIME reveals a tendency to rely on existing instruments or evaluations of new devices designed for broader creative application. We present two examples from our own studies that reveal the merits of designing purpose-built devices for experimental contexts.

Keywords

Experiment, Methodology, Instrument Design, DMIs

1. INTRODUCTION

Experimental methodologies within the NIME community have received greater attention in recent years. Both quantitative and qualitative methodologies for studying Digital Musical Interactions (DMIs) [17], deriving primarily from HCI, have been employed [35]. However, it has been noted [33] that the application of such methods has been limited, consisting of mostly informal user-studies of new and existing DMIs [10, 14, 21, 32, 33], or the creation of theoretical frameworks and taxonomies [4, 25, 27, 28]. Very few studies involving DMIs have employed purpose-built devices specifically designed as an integral part of the study. Rather, they tend to rely on either existing DMIs or devices designed for purely artistic purposes.

This is not to propose that this research has not been beneficial in testing or validating new DMIs or their underlying technologies, or that frameworks have not provided useful language and concepts for considering design. However, part of the reason for the limited reach of formal studies is that it is not obvious how to conduct them in musical contexts; transplanting existing methods from HCI will not always work. In addition, reliable generative frameworks are difficult to validate, especially in a creative domain that lacks easily specifiable evaluative criteria.

In this paper, we characterize the methodological approaches employed in studies of DMIs, as well as the particular choices of devices that have been involved in these studies. Subsequently we detail our experiences in incorporating the design of DMIs as an integral part of larger studies, which requires the designs to be functional and usable, but also to serve the particular goals of the overall studies. From these experiences we suggest new directions for the design of both novel research methods with DMIs.

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2. SURVEY OF METHODOLOGIES

We identify four main methodological styles of NIME studies. Although some certainly exhibit features of more than one, we believe it is an accurate characterization of the field, which reveals substantial space for novel methods.

2.1 Retrospective Taxonomies and Frameworks

Many studies aim to create comparative frameworks for the analysis of design approaches and consideration of features for novel design. These endeavour to provide universal criteria or dimensions upon which to consider all DMIs [3, 4, 25, 27, 28]; focus on specific features such as constraint [24]; or on particular contexts such as collaborative scenarios [5]. The meta-framework presented by Drummond [9] considers the variety of such prior approaches in terms of definition, classification and modelling of interactive music systems. Similarly, O'Modhrain [26] distinguishes between guidelines, frameworks, models and taxonomies, providing a review of prior work along these lines. Frameworks may be generative or analytical, but taxonomies tend to be retrospective. Indeed there are few examples in the NIME literature of generative applications of such studies; the literature has largely sought to categorize and situate existing or newly designed musical devices in the growing body of exemplars. A limitation of this approach, as noted in [4], is that the judgements of criteria that make up taxonomies are partly based on subjective assessments of the devices with little empirical evidence.

2.2 Evaluation of Newly-Designed DMIs

This approach involves post-build evaluation of a new device. These studies address particular issues or evaluative criteria by means of *a posteriori* examination in order to demonstrate utility, usability or functional improvement. This approach draws heavily on classical methodologies in HCI, where quantitative, empirical demonstrations of functional advantages are typically required. However, measurable operational gains are often difficult to demonstrate in creative applications, nor are they always relevant. As such, in the infrequent cases where evaluations of new DMIs are performed at all, they tend to be "informal" [33]. The evaluation of the "Pin&Play&Perform" [6], based on audience feedback, is a typical informal approach in NIME. While the evaluation of the Audiocubes [30] employed a more formalized observational study in an installation setting, it is unclear how this would translate to a performance context.

In contrast, Luciani et al. [23] explored formal qualitative and quantitative methods of how the "ergotic gesture-sound situation" contributes to the overall *playability, believability* and *presence* of virtual instruments.

Several authors have highlighted the shortcomings of applying quantitative usability measures from HCI to DMIs, (e.g., as proposed in [35]), arguing that their inherently reductive nature cannot adequately capture the richness and nuance of real performance scenarios [15, 33]. Stowell et al. [32] attempt to address these shortcomings by demonstrating a formal, qualitative approach to the evaluation of a novel timbre remapping system.

2.3 Evaluation of Existing DMIs

A posteriori evaluations have also been conducted on established instruments such as the Theremin, Radio Baton and Buchla Lightning, typically because of their widespread use and established performance practices. Evaluations tend to assess their ability to support specific properties or features such as expressivity, movement, timing accuracy and repeatability [7, 29, 36]; as well as to substantiate research methods for generalized application [14]. Existing consumer technologies appropriated for musical purposes, such as the WiiMote and mobile phones, have been evaluated in similar contexts [16, 20, 21].

2.4 Evaluations of Underlying Technologies

Another class of study focuses on evaluation of the underlying technologies and techniques of musical devices. An early study focused on establishing the most appropriate input transducers to realize specific musical functions [34]. Gelineck and Serafin [15] similarly investigated the differences between knobs and sliders as control interfaces in a physical modelling synthesis system.

3. AN ALTERNATIVE APPROACH

While this is by no means an exhaustive list of studies with DMIs, it highlights representative methodological approaches, many of which emphasize evaluation of inherent properties or features of existing DMIs. Our approach is distinct in that we are designing DMIs specifically to support research rather than evaluating features of an existing device. These questions demand more than a close examination of a device; rather, the device needs to fill a specific role within an experimental context. Our studies have thus necessitated designing purpose-built devices, which emerges as a very different task than creative design for a performance or artistic purpose [8].

We are not proposing a single and all-encompassing method for the study or design of DMIs. Rather, we present case studies that exemplify an evolving qualitative methodology that necessitates the design of novel devices in order to investigate the broader phenomena that underlie digital music interactions. Nor do we suggest that our designs do not afford artistic use. As we discuss below, we have found that for a variety of reasons the experimental contexts appeared to help performers develop and explore creative practices, although we stress that this is not our primary focus but a by-product of the methodology.

A small number of studies in NIME reflect aspects of our approach. The A20 [1] was created during a study on participatory design and evaluation, however the design emerged over the course of the study – it was an outcome rather than a prerequisite. Gelineck and Serafin's approach [15] is similarly allied in that the devices involved were designed expressly for their study. However, they consider these controllers to be "low-level interfaces" for the purpose of evaluating individual transducer elements, as opposed to performance-ready instruments. Perhaps most similar to our approach, the Spinotron was developed according to constraints and criteria dictated by the goals of a study investigating the design of continuous sonic feedback and quantitative methods for evaluating sound design [22]. In a perspective similar to that in [15], a purpose-built device is employed to reduce the influence of external variables that might affect experimental results. However, as in [15], the study authors did not consider the Spinotron as a musical instrument in itself: there was no established mapping between the Spinotron and the synthesis engine it drives. Indeed, one aim of the study was to evaluate the effects of controlled variations in this mapping [22].

4. CASE STUDIES

We present two case studies that illustrate our approach to designing DMIs in experimental contexts, highlighting how the context dictated the design process and the resulting artifacts. We show that this is a distinct activity from designing DMIs with artistic motivation, and that existing DMIs developed in other contexts would not have suited our needs. Furthermore, these experiences revealed important considerations for the design of DMIs in general.

4.1 One-Button Instrument Study

The purpose of this study was to explore the relationship between *style* and *constraint* [19]. We previously suggested constrained interactions – those in which the user's possible actions are limited physically, conventionally or perceptually – help spectators distinguish individual stylistic variations from the overall structure of an activity [18]. Ten study participants were to be given a week to practice in isolation with a constrained electronic instrument, after which they would individually play a short solo performance followed by a structured interview about their experiences.

4.1.1 Design Process

The main initial criteria for the instrument were to limit the number of controls and possible gesture-sound mappings. We considered studying existing constrained devices, but the purpose was to examine how style *emerged*; the burden of existing performance practices or conventions with known instruments necessitated the development of a novel device. We wanted the instrument to be minimal not just in terms of controls, but also in terms of suggestions of use.

Our design brief became to create a device that was purposefully minimal, that did not strongly invoke existing musical instruments or performance practices, but that still had an identity as a self-contained instrument. The device that emerged, the one-button instrument, is a "box that goes beep." It consists of a plastic project box with a single momentary button on its top surface. A tone of fixed pitch and amplitude is generated, and an LED is lit, for as long as the button is pressed. Other choices were guided by the desire to suggest a single action – pressing the button to play a beep – but not exactly how this should be accomplished. The rectangular shape of the enclosure lacked an indication of a particular orientation for holding it, or whether it should be held at all. The centrally-located button could just as easily be played with any part of either hand.

One unique aspect of the study context that drove the design process was a deliberate avoidance of considering an intended or normative "style" of use. This lies in stark contrast to typical design processes where specific usage scenarios are developed, and designers aim to direct users to these modes of operation. The design was further informed by the necessity to create 10 hand-assembled copies; the instrument had to operate consistently and reliably for each

participant but remain cost-effective. These factors exemplify why a device designed outside of the context of this study could never have been suitable, and reveal how the constraints of the study influenced not just the instrument's form but also the process of its design.

A first prototype had issues with pitch drift and timbre changes as the battery drained; a power switch was later added in order to preserve the battery over the week that the participants practiced with the instrument. This unplanned compromise resulted in an additional way for participants to manipulate the device, making it slightly less constrained than the ideal, but also gave rise to some of the most interesting and salient outcomes of the study.

We observed that participants found a variety of ways to play the primary feature of the instrument – playing tones with the button. Yet the perceived limitation also led to a surprising variety of techniques in which participants capitalized on "hidden affordances" [12] that were not conceived in the design process. These included: usage of the power switch to achieve timbre modification, exploiting mechanical noise in the spring-loaded button and manual filtering or modulation of the sound by cupping the opening over the loudspeaker. Although these "accidents" were ultimately beneficial in the context of our experiment, they reinforced the fact that even an apparently simple device may give rise to significant complexity.

4.2 Tilt-Synth Study

In contrast to the one-button instrument study, which focused on performer-instrument interaction, this wide-ranging qualitative study [11, 17] sought to understand spectators' experiences of performative digital musical interactions. According to the study's design, we presented spectators from a range of musical backgrounds videos of performances with contrasting instruments and conducted extensive interviews to compile and assess their experiences. Among the qualities we wanted to contrast were the degree to which the instruments would be familiar to participants and the extent to which the interactions would be understood.

4.2.1 Design Process

We chose the Theremin for one instrument in the study because we expected it would be known to some participants – the study deliberately included experts in the field of DMIs as participants – and even for the others, its gesture-sound mapping would be obvious. Conversely, the second instrument had to provide a baseline of no specific prior knowledge of the instrument. It had to offer sufficient complexity that some spectators would not understand how it worked, but that might be accessible to some.

These prerequisites constituted a challenging set of design imperatives. The device that emerged, the Tilt-Synth, is a standalone instrument built from segments of ABS pipe with a speaker located in one end. The synthesis comes from two PWM outputs of an embedded microcontroller activated by discrete switches on the opposite end. A second set of switches toggle between two modes of oscillation. In pitched mode, a two-axis accelerometer allows the performer to continuously control the pitches of the oscillators through the x-y tilt of the instrument, while two radial sliders control an amplitude modulation effect. In the second mode, tilt controls the bandwidth of a chaotic pitch stream.

The Tilt-Synth therefore combines large-scale physical gestures similar to the Theremin – facilitated by the continuous accelerometer control – with fine-grained discrete actions. The physical controls were designed to occupy all of the performer's manual actions and therefore minimize the ambiguity of address [2]. It was conceptually simple for a computer musician to perform and evokes obvious, large-scale actions with simple gesture-sound mapping even with minimal practice. However, the more subtle discrete controls and sonic non-linearity that results from the mode-switching provided some participants with ambiguous and incomplete understanding of its operation. The performer in our study, an experienced musician on acoustic and electronic instruments, rapidly developed a comfortable and distinct style of playing the Tilt-Synth that encompassed all of the features of the instrument.

5. DISCUSSION

Through the design and experimental use of the Tilt-Synth, we found that it takes very little complexity to "confuse" spectators. Even with a preliminary demonstration of the workings of the instrument, some participants in our study, including experts, had a poor understanding of how the device worked. Mode switching and chaotic oscillation were observed as significant contributors to perceived complexity; the fact that the performer could make the same physical action with two different results led to confusion of the gesture-sound relationship. Among some participants, this perceived complexity led to inflated evaluations of the performer's skill and experience with the instrument.

Other participants thought the performer's actions amounted to mere "button-pressing," suggesting the instrument was simple to master. Many concluded the performer must therefore possess intimate technical knowledge of the instrument, rather than bodily skill, in order to produce such a rich variety of sound. There was a similar perception that the performer was not fully in control of the sonic output, that he simply mediated some aspect of an automated system. Without an accurate understanding of the interaction, many spectators found it difficult to assess attributes of the performance such as skill or error. Yet some described a distinct aesthetic experience that drew more on the performative actions and dynamic sonic textures than on an actual understanding of what the performer was doing.

The Tilt-Synth study revealed a great deal about real, individual experiences we think are typical of NIME spectators. Only because the Tilt-Synth was purpose-built for this study were we able to examine the realistic situation in which a spectator watches a performance with a totally unfamiliar instrument and little contextual information. The lack of specific prior knowledge of the Tilt-Synth enabled us to investigate how individuals' diverse backgrounds, domain knowledge and aesthetic sensibilities interplayed with their perceptions of the performance. We could not have gained the same level of insight had we used an existing device or something other than a "real" performance-ready instrument. In contrast, in the same study the established performance practice, simple gesture-sound relation and pure tonal sound of the Theremin clearly drove spectators' expectations of what the performer was or should be doing.

With the one-button instrument, it became apparent that much of the stylistic variation was due to participants leveraging their expertise and drawing on their established musical practices. This revealed a great deal about style, as well as our design process; for some participants we succeeded in imparting an instrumental nature into the device, but one that was not so imbued with meaning as to suggest a singular or prescriptive mode of use or stifle their individual contributions. In this we observed an apparent contradiction to orthodox design principles from HCI. By deliberately not considering or prescribing usage scenarios, we enabled diverse users to develop meanings and styles that drew heavily on their own identities. But this was only possible because of the minimalistic nature of the design. Had

we tried to consider the needs, desires, expectations and experiences of our users it would have been impossible to realize such a minimal design, nor could it have supported the practices of experienced performers with idiosyncratic aesthetic sensibilities. This observation resonates strongly with the advocates for ambiguity and the support for multiple interpretations in design [13, 31].

Our experience with the one-button instrument further demonstrated that when conducting studies with real users in the real world, it is nearly impossible to account for every glitch in the instrument or for all the ways they can be appropriated. For such *in vivo* studies conducted over any length of time, it is therefore important to leave room for these kinds of anomalies or unintended artifacts in the study design. These are likely the very sort of "affective and creative" aspects of music-making that Stowell et al. [33] warn can be lost with reductive quantitative studies.

6. REFERENCES

[1] O. Bau, A. Tanaka, and W. E. Mackay. The A20: Musical metaphors for interface design. In *Proc. NIME*, pages 91–96, 2008.

[2] V. Bellotti, M. Back, W. K. Edwards, R. E. Grinter, A. Henderson, and C. Lopes. Making sense of sensing systems: five questions for designers and researchers. In *Proc. CHI*, pages 415–422, 2002.

[3] S. Benford. Performing musical interaction: Lessons from the study of extended theatrical performances. *Computer Music Journal*, 34(4):49–61, 2010.

[4] D. Birnbaum, R. Fiebrink, J. Malloch, and M. Wanderley. Towards a dimension space for musical devices. In *Proc. NIME*, pages 192–195, 2005.

[5] T. Blaine and S. Fels. Collaborative musical experiences for novices. *Journal of New Music Research*, 32(4):411–428, 2003.

[6] J. Bowers and N. Villar. Creating ad hoc instruments with Pin&Play&Perform. In *Proc. NIME*, pages 234–239, 2006.

[7] M. Collicutt, C. Casciato, and M. Wanderley. From real to virtual: A comparison of input devices for percussion tasks. In *Proc. NIME*, 2009.

[8] P. R. Cook. Remutualizing the musical instrument: Co-design of synthesis algorithms and controllers. *Journal of New Music Research*, 33(3):315–320, 2004.

[9] J. Drummond. Understanding interactive systems. *Organised Sound*, 14(2):124–133, 2009.

[10] S. Fels. Designing for intimacy: Creating new interfaces for musical expression. *Proc. of the IEEE*, 92(4):672–685, 2004.

[11] A. C. Fyans, M. Gurevich, and P. Stapleton. Examining the spectator experience. In *Proc. NIME*, pages 451–454, 2010.

[12] W. Gaver. Technology affordances. In *Proc. CHI*, pages 79–84, 1991.

[13] W. Gaver, J. Beaver, and S. Benford. Ambiguity as a resource for design. In *Proc. CHI*, pages 233–240, 2003.

[14] C. Geiger, H. Reckter, D. Paschke, F. Schutz, and C. Poepel. Towards participatory design and evaluation of Theremin-based musical interfaces. In *Proc. NIME*, 2008.

[15] S. Gelineck and S. Serafin. A quantitative evaluation of the differences between knobs and sliders. In *Proc. NIME*, pages 13–18, 2009.

[16] N. Gillian, S. O'Modhrain, and G. Essl. Scratch-off: A gesture based mobile music game with tactile feedback. In *Proc. CHI*, pages 234–240, 2009.

[17] M. Gurevich and A. C. Fyans. Digital musical interactions: Performer-System relationships and their perception by spectators. *Organised Sound*, 16(2), 2011.

[18] M. Gurevich, P. Stapleton, and P. Bennett. Design for style in new musical interactions. In *Proc. NIME*, pages 213–217, 2009.

[19] M. Gurevich, P. Stapleton, and A. Marquez-Borbon. Style and constraint in electronic musical instruments. In *Proc. NIME*, pages 106–111, 2010.

[20] C. Kiefer, N. Collins, and G. Fitzpatrick. Evaluating the WiiMote as a musical controller. In *Proc. ICMC*, 2008.

[21] C. Kiefer, N. Collins, and G. Fitzpatrick. HCI methodology for evaluating musical controllers: A case study. In *Proc. NIME*, 2008.

[22] G. Lemaitre, O. Houix, Y. Visell, K. Franinovic, N. Misdariis, and P. Susini. Toward the design and evaluation of continuous sound in tangible interfaces: The Spinotron. *Int. Journal of Human-Computer Studies*, 67(11):976–993, 2009.

[23] A. Luciani, J.-L. Florens, D. Couroussé, and J. Castet. Ergotic sounds: A new way to improve playability, believability and presence of virtual musical instruments. *Journal of New Music Research*, 38(3):309–323, 2009.

[24] T. Magnusson. Designing constraints: Composing and performing with digital musical systems. *Computer Music Journal*, 34(4):62–73, 2010.

[25] J. Malloch, D. Birnbaum, E. Sinyor, and M. Wanderley. Towards a new conceptual framework for digital musical instruments. In *Proc. DAFx*, pages 49–52, 2006.

[26] S. O'Modhrain. A framework for the evaluation of digital musical instruments. *Computer Music Journal*, 35(1):28–42, 2011.

[27] D. Overholt. The musical interface technology design space. *Organised Sound*, 14(2):217–226, 2009.

[28] G. Paine. Towards a taxonomy of realtime interfaces for electronic music performance. In *Proc. NIME*, pages 436–439, 2010.

[29] C. Poepel. On interface expressivity: a player-based study. In *Proc. NIME*, pages 228–231, 2005.

[30] B. Schiettecatte and J. Vanderdonckt. Audiocubes: a distributed cube tangible interface based on interaction range for sound design. In *Proc. Conf. on Tangible and Embedded Interaction*, pages 3–10, 2008.

[31] P. Sengers and W. Gaver. Staying open to interpretation: Engaging multiple meanings in design and evaluation. In *Proc. DIS*, 2006.

[32] D. Stowell, M. Plumbley, and N. Bryan-Kinns. Discourse analysis evaluation method for expressive musical interfaces. In *Proc. NIME*, 2008.

[33] D. Stowell, A. Robertson, N. Bryan-Kinns, and M. D. Plumbley. Evaluation of live human-computer music-making: quantitative and qualitative approaches. *Int. Journal of Human-Computer Studies*, 67(11):960–975, 2009.

[34] R. Vertegaal, T. Ungvary, and M. Kieslinger. Towards a musician's cockpit: Transducers, feedback and musical function. In *Proc. ICMC*, pages 308–311, 1996.

[35] M. Wanderley and N. Orio. Evaluation of input devices for musical expression: Borrowing tools from HCI. *Computer Music Journal*, 26(3):62–76, 2002.

[36] N. Ward, K. Penfield, S. O'Modhrain, and R. B. Knapp. A study of two thereminists: Towards movement informed instrument design. In *Proc. NIME*, 2008.