# From miming to NIMEing: the development of idiomatic gestural language on large scale DMIs

Lia Mice
Centre For Digital Music
Queen Mary University of London, UK
l.mice@qmul.ac.uk

Andrew McPherson
Centre For Digital Music
Queen Mary University of London, UK
a.mcpherson@qmul.ac.uk

## ABSTRACT

When performing with new instruments, musicians often develop new performative gestures and playing techniques. Music performance studies on new instruments often consider interfaces that feature a spectrum of gestures similar to already existing sound production techniques. This paper considers the choices performers make when creating an idiomatic gestural language for an entirely unfamiliar instrument. We designed a musical interface with a unique large-scale layout to encourage new performers to create fully original instrument-body interactions. We conducted a study where trained musicians were invited to perform one of two versions of the same instrument, each physically identical but with a different tone mapping. The study results reveal insights into how musicians develop novel performance gestures when encountering a new instrument characterised by an unfamiliar shape and size. Our discussion highlights the impact of an instrument's scale and layout on the emergence of new gestural vocabularies and on the qualities of the music performed.

## Author Keywords

Large Digital Musical Instruments, Idiomaticity, Gesture

## CCS Concepts

•**Applied computing** → **Sound and music computing;** Performing arts; •**Human-centered computing** → *Human computer interaction (HCI);*

## 1. INTRODUCTION

Every year an influx of new digital musical instruments (DMIs) is created. Commercially, existing digital instruments are reissued ever smaller, requiring performance gestures that are familiar but equally scaled down. Artistically, entirely novel instruments are created that explore new realms of materiality and require original, even eccentric, performance gestures. However, with so many options available, how do instrument designers know if just because we can, we should? Are design choices such as size, shape, materiality, tonal layout and sound design influencing the music created on a new instrument in ways we had not imagined? And if so, how do we find out? We hypothesize that the answer can be found in the performances created on new instruments.

To test this hypothesis, we conducted a study in which trained musicians explored and improvised on a new DMI that is unfamiliar in as many ways as possible, with distinctive size, materiality, sound-creating gestural language and sound design. The results are discussed and contextualized to argue that not only do design features substantially influence the performances created on the instrument, they go as far as to influence the perception of the performer.

## 2. RELATED WORK

Musical gesture is defined by Miranda and Wanderley as "any human action used to generate sounds" and includes actions such as "grasping, manipulation, and noncontact movements, as well as to general voluntary body movements" [17, p. 5]. Musical gestures that are well suited for an instrument so as to feel natural are often called "idiomatic" [4]. Tanaka points out that "the lack of history that new instruments enjoy means that what is idiomatic has not yet been defined" [14]. Tahiroğlu et al. surveyed the emergence of idiomatic gestures of a range of DMIs and argue that composing from the basis of idiomatic gestures results in performances rich in style and meaning, the very foundations of valued musical repertoire [13].

While musicians may think when performing an instrument they have full agency over their gestural and compositional decisions, the very existence of idiomatic gestures reveals there is more at play. At a granular level, the framework of idiomatic theory helps explain how an instrument's affordances govern the development of players' gestural languages resulting in music idiomatic to that instrument, that is "distinctive musical dialects made of seemingly prefabricated patterns" [2].

Digital, and indeed all, instruments contain values and scripts that tell us what music can and should be made with them [7]. The music on offer is a result of a combination of the instrument's affordances and cultural knowledge [8]. Visi et al. explored cultural influence on gestural language finding that musicians without violin training asked to mime along to a recorded musical performance using a silent violin resulted in similar performances [16].

Tuuri et al. argue that while gesture functions as an instrument of control ('instrumental control'), the interface design contributes towards 'experiential control' in which the user feels their tacit bodily movement is constrained by an interface ('push' effects) or the interface enables their tacit and spontaneous engagement ('pull' effects)[15]. 'Push' and 'pull' effects have been observed to influence DMI performance technique showing that performers optimise their gestures to correspond with the sensing modalities of the instrument [5]. Musicians playing non-functional mock-up instruments will alter their gestures and imagined sound of



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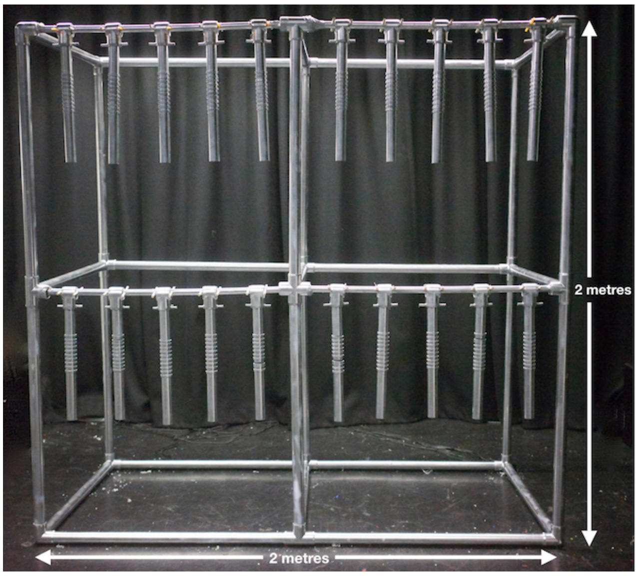


**Figure 1: The study instrument is 2 metres high, 2 metres wide and features 20 performable pendulums that create 20 discrete tones.**

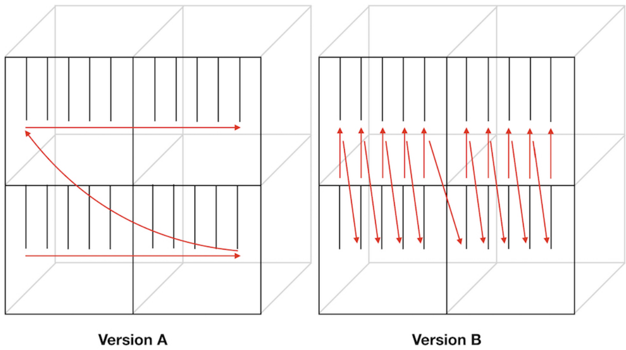


**Figure 2: Both versions of the instrument feature discrete tones that ascend in order with the lowest located on the far left to the highest on the far right, however each version ascends in a different pattern.**

the instrument in response to its material properties [11].

Bin et al. explore the impact of instrument size on perception from an audience perspective [1], however more research is required from the performer's perspective to fully understand the impact of size, tonal layout and sound design on the music and performances created using DMIs.

# 3. METHODOLOGY

We conducted a study in which we monitored classically trained musicians interacting with one of two versions (Versions A and B) of a new large-scale DMI (Figure 1). Both versions are identical in physical construction and sonic affordances but feature different tone mapping (Figure 2). The participants completed three musical tasks. During Tasks 1 and 2 the instrument was turned off, requiring the participants to mime their performances. During Task 3 the instrument was on and amplified through a PA.

## 3.1 Instrument design

### 3.1.1 Physical construction

The instrument is two metres wide and two metres high. It is constructed from PVC pipes and PVC pipe connectors. It features 20 identical pendulums. Each pendulum

**Figure 3: Close-up of pendulums, 50 centimetres long, with ten raised rings at one centimetre spacing.**

is 50 centimetres in length with 10 raised rings spaced one centimetre apart that form textural ridges (Figure 3). The pendulums are located on two tiers (an upper tier and a lower tier), separated by a support beam so as to create four quadrants of five pendulums. Each pendulum features an embedded analog accelerometer. The 20 total accelerometers are connected to the analog inputs of three Bela Minis [9] (as each Bela Mini can accept a maximum of eight analog inputs). Each Bela Mini runs Pure Data code that sonifies the accelerometer signal and the resulting audio is output via three audio cables (one per Bela Mini) to a PA.

Each pendulum was assigned a discrete tone featuring harmonics with a fundamental frequency ranging from 55 Hertz to 1046.5 Hertz (Table 1). On higher pitched tones the harmonics resulted in an electric guitar tone with a bell-like timbre and on lower pitched tones the timbre was similar to an electric bass guitar. A discordant cacophony of tones is achievable by interacting with the pendulums or instrument frame in such a way that the frame will vibrate.

**Table 1: Instrument tones.**

| Tone number | Hertz | Note name | Tone number | Hertz | Note name |
|---|---|---|---|---|---|
| 1 | 55 | A1 | 11 | 164.81 | E3 |
| 2 | 69.295 | C#2 | 12 | 174.61 | F3 |
| 3 | 77.781 | D#2 | 13 | 207.65 | G#3 |
| 4 | 92.499 | F#2 | 14 | 233.08 | A#3 |
| 5 | 103.82 | G#2 | 15 | 261.63 | C4 |
| 6 | 116.54 | A#2 | 16 | 415.31 | G#4 |
| 7 | 123.47 | B2 | 17 | 440 | A4 |
| 8 | 130.81 | C3 | 18 | 554.37 | C#5 |
| 9 | 138.59 | C#3 | 19 | 622.25 | D#5 |
| 10 | 155.56 | D#3 | 20 | 1046.5 | C6 |

### 3.1.2 Hardware and software

Each accelerometer is sampled at audio rate and configured to have a natural analog bandwidth of approximately 1kHz with a first order roll off. In the Pure Data code, each of the accelerometers' Y axis data (responding to the

**Table 2: Table of participants.**

| Participant | M/F/NB | Primary instrument | Years of lessons | Other instruments | Primary style | Study instrument |
|---|---|---|---|---|---|---|
| P1 | M | Guitar | 3 | Drums | Rock, popular music | A |
| P2 | M | Drums | 3 | Piano, tympani, glockenspiel | Prog rock | B |
| P3 | M | Bass guitar | 1 | Piano, saxophone, synthesizer | Rock | B |
| P4 | M | Piano | 14 | Trumpet | Free improvisation | B |
| P5 | M | Guitar | 2 | Drums, piano, tuned percussion | Folk music | B |
| P6 | F | Synthesizer | 10 | Piano, gong, drums | Experimental | A |
| P7 | F | Piano, keyboard | 7 | Guitar | Classical, popular | A |
| P8 | F | Piano | 4 | Cello, synthesizer, sampler | Cinematic, electronic | A |
| P9 | F | Guitar, piano | 8 | Voice, synthesizer, sampler | Post punk | A |
| P10 | NB | Guitar | 0 | Violin, keyboards, drums, voice | Alternative rock | B |

forwards-backwards angle of the pendulum motion) excites a Karplus-Strong algorithm, based on open source Pure Data code created by Neupert et al. [6, 10]. The code is configured such that a brighter tone is created by striking a pendulum with more force, and a tone with longer sustain is created by striking a pendulum while holding it at an angle up to ninety degrees, the maximum afforded by the physical construction.

## 3.2 Study design

The study was a structured one-to-one interview-based study. The interviews lasted one hour each, during which time the trained musicians were introduced to the new instrument for the first time and given musical tasks to perform on the instrument. After each task the participants were asked to elaborate on the choices they made while completing the tasks. The interviews and musical tasks were recorded with video cameras from multiple angles.

### *3.2.1 Participants*

We recruited ten participants, of whom seven were trained pianists, five were trained percussionists and five were trained guitarists (Table 2). An equal number of percussionists and keyboard players were assigned each version of the study instrument. Participants' ages ranged from 25 to 69 with an average of 38 years old. The average years of lessons they had received on their primary instrument was eight years for keyboardists, three years for percussionists and two years for guitarists. While all participants were literate in western notation, their primary musical styles varied.

### *3.2.2 Musical tasks*

The participants used the new instrument to complete three musical tasks. In Task 1, the instrument remained turned off for the duration of the task. The participant was given five minutes to explore the instrument, perform gestures and imagine the resulting sounds. They were told to perform a one-minute mimed improvised performance while imagining the sound of the instrument. In Task 2, the invigilator performed the instrument without the participant watching, so the participant could be aware of the range of tones and timbres the instrument is capable of producing. Participants were again encouraged to silently explore the instrument for five minutes in its turned off state, and mime a one-minute improvised performance, however this time with knowledge of the instrument's sound design. In Task 3, the instrument was turned on. The participant explored the instrument for five minutes and created a one-minute improvisation.

The video recordings were manually transcribed and the transcription data was analyzed following a thematic analysis methodology [3]. Codes emerged through a theory-driven iterative process [12], in that the raw interview data was examined for trends and correlations that relate to the theories of idiomatic gestural language and experiential control. Four iterations of coding were performed resulting in a codebook that was updated and refined at each coding iteration. The video recordings of the improvised performances were analysed for performative trends by identifying gestures and patterns participants performed in each task.

# 4. FINDINGS

The themes revealed trends across participants, regardless of their musical background and which instrument version they performed.

## 4.1 Imagined sound design of the instrument

Task 1 required the participants to mime performance on the instrument without knowledge of the digital sounds it makes, and in doing so imagine its sonic affordances. During this task several participants conceptualised similar sound design for the instrument. Seven of the ten participants imagined the DMI to sound like a metal tuned percussion instrument, with several each referring to bells, wind chimes, xylophone and vibraphone. One participant, P4, chose to not imagine tones at all and only perform the instrument with knowledge of their own rhythmic input so that no matter what sounds the instrument makes the resulting music could at least be rhythmically coherent. Even so, he said he initially thought the DMI might sound like a bell until he realised the instrument is not made of metal, only painted to look that way. Four participants imagined sounds inspired by wind moving through pipes, and one imagined sound design of metal scraping on metal, such as the sound of a squeaky gate. Two participants imagined percussive tones reminiscent of a güiro. Four participants imagined ambient, soundscape or found sound samples.

Three participants imagined a deep bass tone. P7, a pianist, imagined the instrument to sound like a piano but no participants imagined the instrument to sound like a guitar. Upon hearing the DMI only one participant, P10, commented that the instrument featured a tone they had imagined, saying "I was really gratified that this had within it that kind of dark tone that I was hoping to hear... I was right in imagining this was a sci-fi instrument."

## 4.2 Familiarity of instrument

When commenting on the sound of the DMI and how it compares to other instruments, six participants said it has features reminiscent of tuned percussion instruments such as melodic drums, thumb piano, cymbals, bells or tubular bells, and seven participants commented it has some sound design features similar to a string or extended string instrument such as an electric guitar, sitar, saz, prepared piano or prepared harp. Six participants said the DMI is unlike any other instrument they have ever performed. Common reasons for its distinctiveness are that it is performed in a physical, percussive manner but has the detailed sonic affordances of an electric string instrument. P10 said the raised rings on the pendulums are like the coils of a guitar string if the guitar string was enlarged to the size of the pendulum.

## 4.3 Tonal layout of the instrument

During the first two tasks, all participants imagined that each pendulum has a unique tone and the tones are arranged in a predictable order. Two participants imagined the tones ascend to form a pentatonic scale, two imagined a chromatic scale and two imagined a scale neither pentatonic nor chromatic. Three participants imagined the tones to be ordered with the lowest tones in the centre and highest tones on the outside, inspired by the tuning layout of the metal tine instrument the mbira. During the final task when the instrument was turned on, five participants correctly identified that the lowest tones are located on the left and the highest tones on the right, however no participants identified the exact pattern of tonal ascension. Six participants commented that they found the pitches to be in an unexpected or confusing order.

Visually, the instrument frame creates an aesthetic of two tiers separated into four quadrants containing five pendulums each. While discussing the tonal layout of the instrument, eight of the ten participants referred to the tiers and nine of the ten participants referred to the quadrants in comments that revealed they assigned significance of the tiers and quadrants to the instrument's tonal layout. During the mimed tasks, four participants imagined lower tones located on the lower tier and higher tones located on the upper tier, while five participants imagined different tones and/or timbres to be located on each tier but not necessarily the low tones on the lower tier and the higher tones on the upper tier. Five participants imagined each quadrant features a different register or range of tones, and one participant (P9) imagined each quadrant features a different instrument such as a sampler in one quadrant and a synth in another quadrant.

After Task 3, P3 said he performing the central upper tier pendulums because he like the pitch range there. Similarly, P10 was particularly drawn to a certain quadrant because it has a "Turkish saz vibe" and a range similar to an electric guitar. P10 commented that pendulums in a particular quadrant "made really outrageous noises" and "seemed so much less melodic" than pendulums in other quadrants. "I was trying to create a groove and I thought those (pendulums) are going to disrupt that". Both P3 and P10 performed Version B.

P5 and P8, who performed Version B and Version A respectively, both commented that they don't think the order of the tones in the quadrants on the left follow on to the quadrants on the right, implying that the central support beam signifies a discontinuation of the tonal layout. In all, six of the participants referred to the quadrants as a way of describing groups of tones. The reality is the tones ascend in order irrespective of the quadrants.

## 4.4 Playing techniques

Table 3 shows emergent playing techniques and how many participants performed each technique per task. Notably, striking the instrument with the soft end of the mallet was performed by all 10 participants. Six other gestures were performed by five or more participants, including striking the instrument frame (8 participants), scraping the hard end of the mallet over the pendulum rings (7 participants) and striking with the hard end of the mallet (7 participants).

With each task the participants expanded their gestural languages. In Task 1, by default all ten participants performed gestures they had not performed before. In Task 2 and again in 3, seven out of ten participants performed a new gesture they had not previously performed. It is to be expected that participants would discover new gestures in Task 3 as a result of the sound being on, and five participants reported knowingly doing so. We find it interesting that two participants, P6 and P7, developed new gestures during Task 2 after discovering the instrument is capable of creating more timbres than they had originally imagined.

**Table 3: Number of participants that performed each gesture in Tasks 1, 2, 3 and all tasks combined.**

| Gesture | Task 1 | Task 2 | Task 3 | All tasks |
|---|---|---|---|---|
| Strike pendulum - soft end of mallet | 10 | 9 | 8 | 10 |
| Strike frame - mallet/hand | 5 | 4 | 6 | 8 |
| Strike pendulum - wooden shaft of mallet | 3 | 4 | 3 | 7 |
| Scrape pendulum rings - wooden shaft of mallet | 4 | 4 | 5 | 7 |
| Push pendulum - hand | 4 | 6 | 2 | 6 |
| Upward strike to pendulum - mallet/hand | 4 | 2 | 3 | 6 |
| Scrape pendulum rings - soft end of mallet | 3 | 4 | 3 | 5 |
| Scrape pendulum rings - hand | 4 | 1 | 1 | 4 |
| Strike pendulum - mallet, and pendulum returns to mallet | 1 | 2 | 2 | 4 |
| Tap pendulum - hand | 1 | 2 | 1 | 3 |
| Hold pendulum at an angle and strike - mallet/hand | 0 | 2 | 3 | 3 |
| Hold pendulum at an angle | 0 | 2 | 1 | 2 |
| Strike inside pendulum - hand | 1 | 1 | 1 | 2 |
| Strike inside pendulum - wooden shaft of mallet | 0 | 1 | 1 | 2 |
| Catch swinging pendulum | 1 | 1 | 0 | 2 |

Table 4 shows the number of pendulums each performer played per task. We find it interesting that each participant performed on average 18, 16 and 19 pendulums during Task 1, 2, and 3 respectively, making almost full use of the 20 tones on offer regardless of whether the sound was on.

In addition to trends of sound producing gestures, trends of compositional patterns emerged in which participants were observed to perform the same combination of tones in series. Table 5 shows the patterns that participants were observed to play, and how many participants performed each pattern per task. All ten participants performed at least one of these patterns during each task.

Five of the patterns ("quadrant in order", "adjacent quadrant patterns", "quadrant sweep", "simultaneous or alternating neighbours" and "tier in order") were performed by participants on both versions of the instrument during Task 3 with the sound on, thereby resulting in different sonic output. The most performed patterns are achievable with

**Table 4: Number of pendulums performed per task.**

| Participant | Task 1 | Task 2 | Task 3 |
|---|---|---|---|
| P1 | 20 | 20 | 17 |
| P2 | 19 | 20 | 20 |
| P3 | 11 | 6 | 18 |
| P4 | 20 | 20 | 20 |
| P5 | 20 | 18 | 20 |
| P6 | 20 | 20 | 20 |
| P7 | 20 | 13 | 20 |
| P8 | 14 | 13 | 20 |
| P9 | 16 | 10 | 13 |
| P10 | 20 | 18 | 20 |
| Mean average | 18 | 16 | 19 |

Table 5: Patterns of tones performed in order and how many participants performed each pattern per task.

| Pattern | Task 1 | Task 2 | Task 3 |
|---|---|---|---|
| Quadrant in order: 5 pendulums located in the same quadrant performed in order, strike gestures | 8 | 8 | 7 |
| Adjacent quadrant patterns: a sequence of pendulums in a quadrant repeating in another quadrant | 8 | 7 | 4 |
| Quadrant sweep: 5 pendulums of same quadrant, 1 arm motion | 8 | 3 | 3 |
| Simultaneous or alternating neighbours: performing two pendulums next to one another | 4 | 6 | 5 |
| Tier order: 10 pendulums located on the same tier consecutive order, strike gesture | 3 | 4 | 4 |
| Tier sweep: 10 pendulums of same tier, 1 arm motion | 4 | 1 | 1 |
| Furthermost stretch: performing the furthermost left and right pendulums on one tier simultaneously | 2 | 0 | 0 |

relative ease, such as the sweeping motions that results in many notes performed in order with the one arm gesture. By contrast, the least frequently observed pattern was the most difficult to perform ("furthermost stretch").

## 4.5 Physicality of the instrument in relationship to the performer's body

Five participants remarked on how large the instrument is, saying "it's easily the biggest instrument I've ever played" (P3) and "I can't believe how large it is, and I think that could be slightly intimidating" (P6). Two of the participants commented on its potential to be dangerous, with P2 demonstrating "if it's swinging like this you have to be careful it doesn't hit you in the face".

Three participants commented that they chose to perform pendulums that were more ergonomically suited to their body. Five participants said they relocated themselves to a different part of the instrument to perform pendulums that were in their preferred tonal range.

Seven out of ten participants consistently performed from outside the instrument's frame (Table 6). Of these participants, three performed only ever facing the pendulums, without exploring the side or back of the instrument.

Table 6: Number of participants who performed from each location per task.

| Performer location | Task 1 | Task 2 | Task 3 |
|---|---|---|---|
| Outside frame, facing pendulums | 8 | 7 | 7 |
| Inside frame, facing pendulums | 5 | 3 | 3 |
| Left, right and/or behind frame | 3 | 1 | 2 |

Three participants chose to perform all tasks from inside the instrument's frame (Figure 4) with one (P8) not even exploring the options of performing from any other location. All three complained that the instrument design features horizontal support beam dividing the left and right sides of the instrument, restricting their access to each side as they would need to duck below it to cross the divide. This resulted in them either focusing their improvisations on one half of the instrument, or choreographing ducking movements into their performance. Ironically if they had chosen to perform from the outside of the instrument they would not have been restricted by the support beam.

Figure 4: Three participants performed all tasks from inside the frame even though this restricted access to the other side of the instrument.

# 5. DISCUSSION

It is evident that the instrument's materiality, aesthetics and sound design influence the emergent gestural language and in turn the initial music improvised on the instrument.

## 5.1 Impact of materiality on imagined sound

When imagining the DMI's sound, nine of the ten participants were influenced by the instrument's materiality such as the pendulum rings that brought to mind güiro-inspired sounds and the metallic aesthetic that evoked sounds and tonal layouts of metallic instruments. These results reinforce Pigrem et al.'s findings that performers' expectations of a DMI's sound and function are fundamentally linked to their tacit and cultural knowledge of materiality [11].

## 5.2 Impact of sound design on development of gestural language

Participants discussed ways in which the sound design influenced their methods for developing performance gestures. P3 and P5 discussed abandoning previous gestures when they discovered they did not result in sound. P2 described changing to easier techniques that result in the same sound. For instance, when he discovered the swing of a pendulum does not change its tone he left pendulums swinging, when previously he tried to stop each pendulum. P4 and P10 both described their techniques as trying every gesture then focusing on those that result in sound, "eliminating movements that are not useful, and trying to find the ones that were" (P10). With the sound on, P10 played with more precision and variation, explaining "I was testing much more subtle kind of movements, when originally I thought they might just make one sound but it seems that they're more interactive with velocity". These comments illustrate Jack et al.'s research into musicians optimising their gestures to match the sensing modalities of instruments [5].

## 5.3 Impact of sound design on improvisation

In Task 1, P8 imagined the instrument's tones would sustain so she performed gestures at a slow tempo. In Task 2, after hearing the shorter-than-expected instrument tones, her gestures sped up. She said her decision to increase the tempo was based on a preference for tones to finish before new ones begin. This demonstrates how an instrument's sound design can impose 'pull' effects that control the performer to change the speed of their performance.

## 5.4 Impact of instrument physicality on compositional choices

P6 commented that she was unsure whether she played a pendulum because she likes its tone or whether she likes its tone because it is in an ergonomically convenient location. Meanwhile, P8 justified moving around the instrument a lot by saying "you've got this big machine, you don't want to just stay there. You want to... use the breadth of the machine". These examples illustrate Tuuri et al.'s research on experiential control [15] as the physical size of the instrument in relationship to the performer's body results in 'pull' effects that control which pendulums the performer plays and in turn how they move their body.

### *5.4.1 Impact of tonal layout on improvisation choices*

Identical patterns of successive tones were observed to be performed by different participants. As these compositional patterns were performed on both instrument versions regardless of tonal layout, therefore resulting in different sonic output, we propose to identify them as the instrument's idiomatic gestural patterns.

Patterns occurring across more than one quadrant more frequently combined quadrants located above or below rather than beside one another. Performing quadrants side by side requires much more movement than performing quadrants above one another. This trend indicates that what is idiomatic to this instrument has less to do with sound design and more to do with the instrument's physical layout and its relationship to the body.

Beyond influencing emergent idiomatic patterns, the visual aesthetic of the quadrants even influenced the performer's perception of the tones themselves. This is illustrated by the examples of the participants that performed Version B of the instrument who were drawn to certain quadrants and avoided others. Version B features a zigzag tonal layout such that the upper and lower tiers have a similar range of pitches and timbres.

## 6. CONCLUDING REMARKS

While there is an influence of sound design on performance techniques, the idiomatic gestures and patterns that emerged seem to be strongly dependant on the relationship between the instrument's physical layout (a combination of the tonal layout and size) and the human body, resulting in strong influence on the improvisations created and moreover even resulting in musicians changing their perception of the sound.

In this paper we have introduced a study that observed the initial reactions of trained musicians when encountering a new, unfamiliar, large scale DMI for the first time. The study resulted in the identification of several idiomatic gestures and idiomatic patterns of the instrument as well as new insights into how the layout, materiality, sound design and size of an instrument govern performance choices. The study revealed that sound design influences both idiomatic gestures and idiomatic patterns, yet some idiomatic patterns are so inherent to an instrument that if disrupted by replacing tones with other tones, musicians perform the idiomatic patterns regardless of the tones and even perceive the tones differently which in turn influences their use in performance. These findings illuminate how the size and layout of a DMI influence the instrument's idiomatic gestures and idiomatic patterns, which in turn influence performances created on the instrument.

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