Enabling Embodied Music-Making for Non-Musicians

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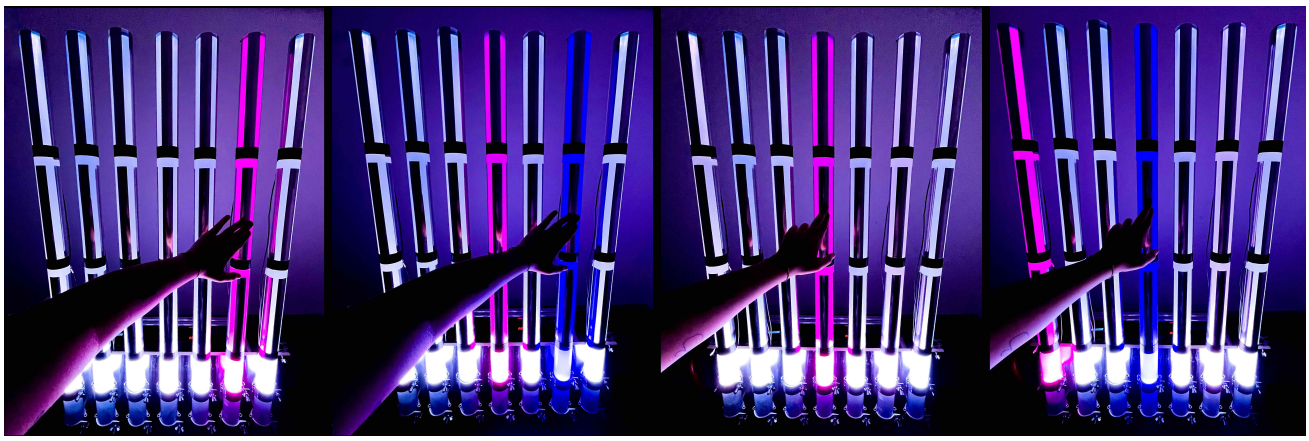

Figure 1: Chord progression mode in the Tubularium. The pink light indicates the next chord in the progression. When the tube is touched, the light turns blue and the system advances to the next chord, illuminating in pink the corresponding tube.

Abstract

We present a Research through Design exploration of the potential for using tangible and embodied interactions to enable active music experiences - musicking - for non-musicians. We present the Tubularium prototype, which aims to facilitate music-making to non-musicians by not requiring any initial skill while still eliciting agency and overall, providing a meaningful experience. We present the design of the prototype and the features implemented and reflect on insights from a public event in which the prototype was trialed.

Keywords

Embodied Interaction, Tangible Interaction, Musicking, Non-Musicians, Research through Design

1 Introduction

Advances in music technology have brought rich opportunities for experiencing music and facilitated a so-called music democratization process [32, 66]. However, they have also brought a *passivization* in how we experience music [30], treating music more as a medium for passive listening than as an *activity* to participate in. In this study, we draw inspiration from Christopher Small's argument that music should be an active process for anyone involved in the experience: *musicking* [61]. For Small, the performance is central to the experience of music: "a performance does not exist in order to present musical works, but rather, musical works exist in order to give performers something to perform" [61, p.8]. Those who play instruments or compose have inherent access to these active experiences. However, mastering a traditional instrument requires training and many years of practice, posing a large obstacle to active participation in music making [43].

A second source of inspiration is Mice and McPherson's [44] observation that digital music instruments have grown ever smaller, whereas human bodies have not changed - drawing our interest towards building a larger instrument that can be interacted with through full body movements.

We present a Research through Design [22] project exploring how to create a novel, full-body sized musical interface for non-musicians. We present the design of Tubularium, a tangible interface with features tailored to support active and embodied music-making. An evaluation of the artifact is also carried out, in which we enquire about the qualities of the experience with the artifact. The insights from this evaluation are discussed as annotations in light of the main themes identified, focusing on participants' embodied interactions with the artifact.

2 Related work

2.1 Designing for aesthetic experiences and for the body

Over the past two decades there has been increasing attention in HCI research towards aesthetic experiences [2, 24, 41, 53]. HCI research has often been carried out in collaboration with artists [3, 18, 31], sometimes challenging the boundaries between HCI research and art [10, 35, 60]. Much attention has also been given to multisensory experiences [50, 68] and somaesthetics [16, 26, 28, 55].

Within the field of New Interfaces for Musical Expression (NIME) [19], aesthetic experiences have been discussed to make more explicit the role of aesthetics in the design of new interfaces [37], and discussed through multisensory experiences [9, 25, 67].

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Morreale et al. [45] also worked on defining a framework centered on players' experience in the context of music interfaces, highlighting the importance of looking into the goals of the experience through the lenses of the people, the activity and the context.

Much research in NIME has focused on tangible and embodied interactions [11, 44, 65, 70]. Designing tangible interfaces involves designing for the digital and physical as well as for the relationships between these spaces. There are multiple studies on tangible interactions for music interfaces such as tabletops [20, 34, 51] and blocks [59, 69]. This emphasis on embodiment naturally extends to somaesthetics [40, 44, 54, 63], often making the body as the instrument [6, 11, 39, 48, 64]. In "Super Size Me", Mice and McPherson [44] recall the trend of shrinking digital musical instruments despite humans remaining constant in size. This imbalance led them to design a large, human-sized instrument.

This focus on embodiment and multisensory engagement aligns with foundational design principles for Digital Music Instruments (DMI), which consider the interplay between expressivity, skill, accessibility, and the unique relationships between musicians and their instruments, emphasizing the importance of supporting diverse user needs, fostering creativity, and addressing the challenges of designing for both technical functionality and artistic expression [15, 30, 47, 48, 56].

2.2 Designing for non-musicians

According to Jordà [33], early research in NIME tended to target expert users and focus on developing interfaces that permit improvisation, experimentation, and the performance of a range of different pieces of music. Blaine and Fels [5] provided an overview of the design considerations when working with novices, which also served as a precedent for further research on collaborative interfaces for novices [8, 71]. McPherson and colleagues [42] reviewed the development of devices for novices based on crowdfunding platforms as well as academic research and found a wide variety including MIDI controllers, self-contained synthesizers, augmented instruments, and toolkits. Nevertheless, their analysis of NIME proceedings from 2012 to 2017 found that only 31 out of 693 papers introduced new interfaces aimed at musical novices or general subjects [42, p. 187], highlighting that there was still relatively little work directed at musical novices within NIME in this period.

Murray-Browne [46] suggests a distinction between Digital Music Instruments (DMI) - denoting the hitherto dominant paradigm in NIME - and Interactive Music Systems (IMS), borrowing the terminology from Rowe [58]. IMS are systems built for non-expert users, that take input from the users and respond with music. Murray-Browne highlights Gelinek and Serafin's work on explorability [23], suggesting that an IMS should encourage explorative behaviour whilst being intuitive enough to give the confidence to continue. This presents an interesting tension when designing an IMS [46]: The closer an IMS is to a known music instrument, the more familiar it is to interact with. But at the same time, the participants may expect the IMS to behave just like the instrument, which in return could create a misalignment in the expectations of what the IMS does.

There is a history of commercial products for musical novices, such as the Hotz Box [27] included translator software designed to eliminate the need for knowledge of music theory. The concept of music translation is now a common feature in current devices with grid controllers [29, 38, 49]. Currently there are sequencers available that aim to support explorative behaviour, but these often turn out to be either overly complicated for beginners [36] or meant to be used as a compositional tool [57]. A remarkable device is Dato Duo [13], a sequencer and synthesizer designed for all ages, in which the musical possibilities have been limited to a single pentatonic scale.

3 Methodology

This project has followed a Research Through Design [22] approach in which we explore the insights that come out of the design process and the designed artifact. While the artifact reflects design choices informed by theory, theory does not necessarily prescribe or dictate the design. Rather it serves as annotation, explaining and providing context for the design choices embedded within the artifact.

3.1 Design Principles

The study was inspired by our personal experience as amateur musicians and the rush experienced during a performance when being in "flow" [12]. We had the desire of creating an opportunity for individuals without musical expertise to have an aesthetic experience through music-making. Without aiming to create an educational tool but rather an experience-focused artifact, we defined a set of design principles, based on our reading of past research, to guide the design process, which will be introduced below.

Design Principle I: The system should help non-musicians create melodious sounds without requiring any initial skill. Musicians make use of music theory notions as a starting point to balance and manipulate the elements in music. To facilitate music-making for those who don't have prior skills, the artifact needs to support novices with these notions. Besides providing support, the artifact should remain intuitive and have a low-barrier entry whilst providing enough space for exploration and creativity.

Design Principle II: The interaction should elicit a sense of agency and ownership of the sounds generated. Agency is a key factor when designing interactive interfaces [4]. There is a trade-off between the demand for simplicity set out in Design Principle I, and the need for agency: The system must support the user in the process but also must provide the user with enough control to meet the user's expectations of agency.

Design Principle III: The design should facilitate a meaningful music experience. To provide a meaningful and memorable experience the artifact needs to appeal to the senses and emotions, immersing users in the music-making process.

4 Tubularium

The Tubularium, shown in Figure 2, was designed to allow novices to easily play harmonious sounds, but also with an intentional ambiguity in order to encourage a diversity of approaches to touching and playing.

The physical artifact is made out of seven acrylic opal tubes which each have three distinct sensing areas, delimited by vertical stripes of electrical conductive tape. Each tube contains an RGB LED connected to a DMX controller, complementing the sound as feedback for the interaction. The 7 tubes in the Tubularium represent each of the notes within a heptatonic scale, and the three sensing areas correspond to three octaves. The artifact measures 75 cm in width and 110 cm in height, and is elevated so that the middle row aligns with eye level. It is meant to be played

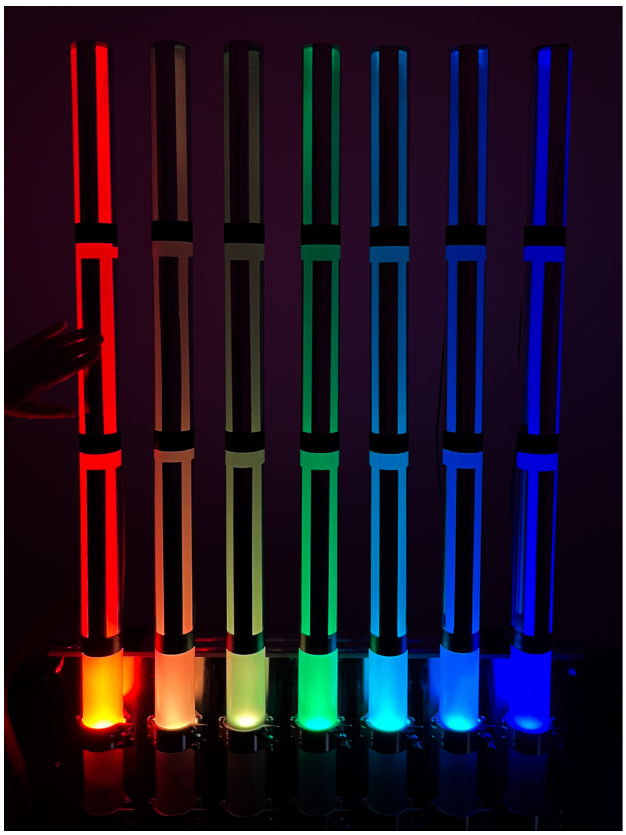

Figure 2: The Tubularium.

Figure 3: The controlling interface.

by positioning yourself facing the tubes and giving your back to a possible audience, to give a sense of intimacy between the artifact and the player. The tubes have a diameter of 5 cm, with a 10 cm spacing between their centers, making them easy to grab with the hands and enabling rapid transitions between them.

The controlling interface (Figure 3), made of acrylic laminates, contains a TFT LCD round display, a switch, and several potentiometers and push buttons.

The Tubularium helps novices to easily play harmonious sounds through a 'chord progression' mode, as shown in Figure 1. When the user touches the sensing area the system plays a chord with the corresponding note as the base, and the light within the tube lights up blue. The lights inside the tubes also indicate the next chord in the progression: The next tube the player should touch shines pink. This mode supports the exploration of chord progressions rhythmically, by alleviating the user from having to play (and know) all the notes in a chord and instead letting them focus on the rhythmic patterns or the*strumming*.

The artifact can also be played in single-note mode, where each input triggers a single note. Several tubes can be touched at a time, making Tubularium polyphonic. This mode allows the user to explore melodies, create a lead, or even improvise a solo, through real-time play and a history-keeping mechanism.

The control interface features knobs for controlling sound (timbre), emotion, and key. The players can explore 32 different timbres. The emotion knob shows on the controller screen as emoticons in incremental positive arousal and valence. This feature encourages the user to explore how different scales and chord progressions can evoke different emotions. The key knob transposes the pitch up or down. The controller also has push buttons for recording and playback. The history-keeping mechanism is set to only save the latest recording to prompt the user to focus on live playing rather than on sequencing or remixing.

In order to help users experiment and create rich melodies, we also implemented an AI co-creation mode which allows the user to jam with an AI improvisation based on their own recording. In order to use this feature, the user must first make a recording. When the AI button is pressed, the recording is sent to a Hidden Markov Model based on an existing patch [52] which uses the MAX/MSP object [ml.markov] [62]. The model returns an endless improvisation based on the user's recording. This improvisation can be played back simultaneously as the user keeps playing.

The Tubularium is controlled by custom software made using the visual programming language Max/MSP [1]. It comprises a main patch with three sub-patches: one for communication handling via serial ports with a custom protocol, and the others for single-note and chord progression modes, managing the dynamic mapping and additional features. The communication patch handles the signals from the sensing areas in the Tubularium as well as the controlling interface. The value from the sensing area is mapped to a note and associated with a fixed velocity value. The resulting note is calculated based on the key and the scale. Each scale has a different mapping. The following scales are available: Natural Major, Natural Minor, Harmonic Major, Harmonic Minor, Major Blues and Minor Blues. Figure 4 shows an example of the mapping for the system when the scale is set to major and the key is set to C.

When the system is set to single-note mode, a MIDI message is created based on the note obtained from the mapping and a fixed velocity. In the chord progression mode, each tube represents the Roman numeral chord of the key, having the note value of the sensing area touched as the root note of the chord. For each scale, a popular chord progression has been selected. This chord progression is shown by lighting the tube corresponding to the chord. Once that tube is touched, the indicator light moves to the next chord. The MIDI messages are then sent to a plugin of Dexed [21], a popular Frequency Modulation (FM) Synthesizer. The plugin is loaded with a cartridge with a broad variety of sounds intended to inspire music-making.

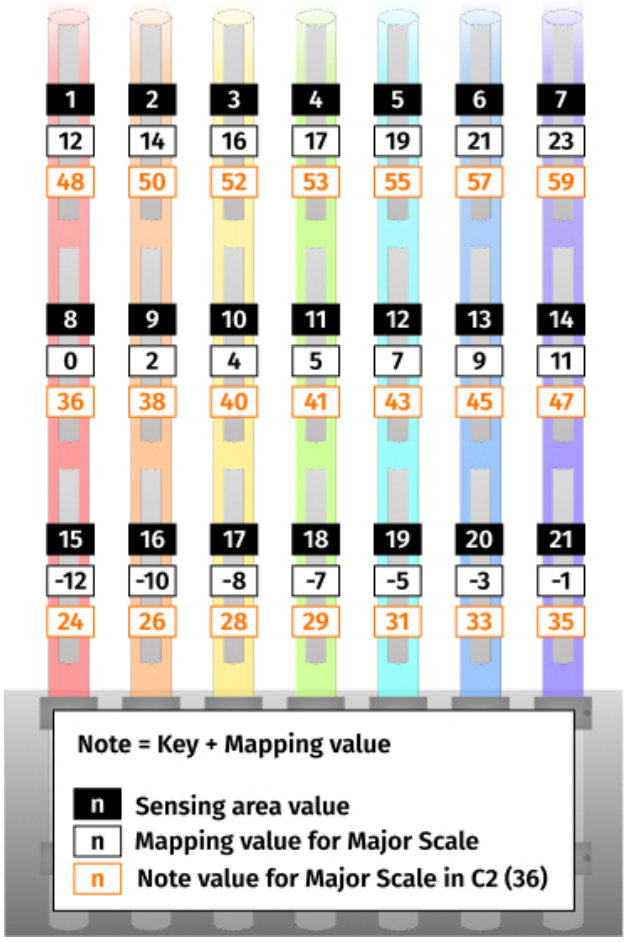

Figure 4: The mapping of the Tubularium exemplified

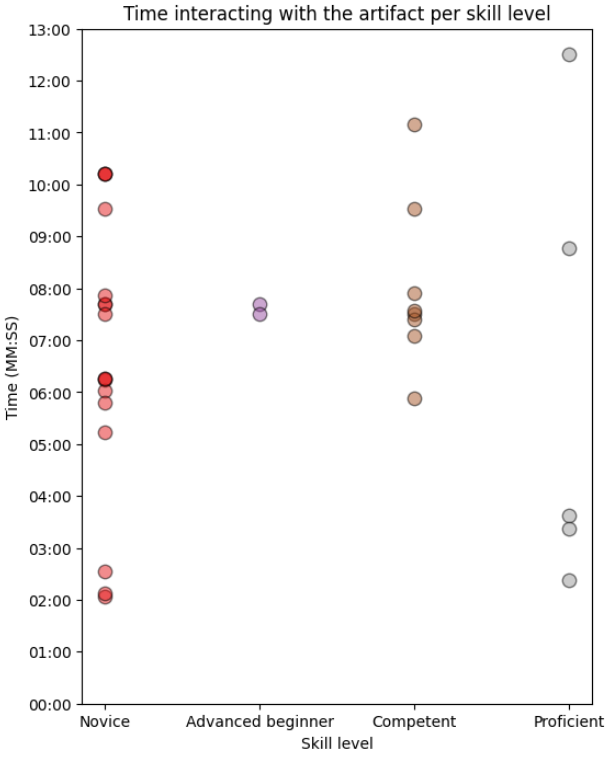

Figure 5: Time spent interacting with the prototype per skill level. Each dot represents a participant.

5 Evaluation

The Tubularium was evaluated by 32 participants recruited at a local youth cultural center over four days in July 2024. The evaluation aimed to assess whether the Tubularium facilitated an experience that lived up to the three design principles outlined in Section 3.1 above.

Before interacting with the Tubularium the participants completed a short questionnaire, in which they were asked to self-assess their musical skills using the Dreyfus model [17]: 17 participants identified as Novices (see Table 1). The median age was 30 (range: 7-58). 15 participated alone, while 17 participated in groups of 2-4.

Participants were given a short explanation of how to interact with the artifact and were instructed to explore it freely for as long as they wished. The participants' interactions with the artifact were recorded on video for later analysis. Once the participants decided to stop, a short semi-structured interview took place. The interviews were audio-recorded and transcribed.

In order to assess how memorable the experience had been - a key concept in Dewey's theory of aesthetic experiences [14, 41] - participants were contacted one month later for a brief follow-up interview. This took place over the phone and was completed by 10 participants.

The data collected were analysed using Thematic Analysis [7]. Below, we present outcomes of the evaluation regarding the three design principles outlined previously.

5.1 Design Principle I: Skill-free

When participants first saw the Tubularium, they were very keen on interacting with it. Many exclaimed in excitement and then went quiet, focusing on figuring out how the artifact worked. During their explorations, many were carrying the rhythm with their feet or by snapping their fingers. Some made small dance movements, and some imitated the sounds coming out of the speaker. All participants managed at some point to make melodious sounds, but mostly they seemed more focused on exploring the variety of sounds that they could make. On average, the participants spent 7 minutes using the prototype (see Figure 5).

In the interviews, participants from all skill levels indicated that the intuitiveness of the system was a key factor in making interesting sounds: *"I like that I can record and play and it's easy for me to [...] make something that actually is enjoyable to listen to"* (P23, novice). Another participant praised the mapping and the note distribution as a key factor for the system's intuitiveness: *"You quickly got an idea of which notes were high pitch notes. So it was really easy to use"* (P26, novice). Another said that what they were making resembled what they are used to hearing, motivating them to further engage in music-making: *"It makes you want to make music [...] It sounds a lot like the music you know and it makes you want to try and jam"* (P19, novice). Also the more skilled users agreed on the intuitiveness, recalling the mapping in scales as a key feature to keep the sound possibilities harmonious: *I think the design of it makes total sense with the octaves. [...] You don't need that much knowledge to make some melodies that make sense"* (P7, proficient).

	Novice	Advanced beginner	Competent	Proficient
N. of participants	17	2	8	5
Avg. duration (mm:ss)	06:41	07:36	08:00	06:08

Table 1: Overview of the participants, their self-assessed skill level and average duration of the interaction.

5.2 Design Principle II: Agency

During the performances, we observed that participants try to make sense of the interactions by building a mental model based on their perception and previous experiences with musical instruments. This sense-making process could be seen when some of them went up and down or left to right, touching all the sensing areas during the first moments of the interaction.

The controlling interface created confusion for some participants, and while some decided to ask about the different controls, others were determined to figure it out on their own. This made some participants feel like they were missing control. Some found this enjoyable: *"You don't know what happens when you touch the different things. But that's kind of the playful thing of it"* (P22, novice); but others felt frustrated because of the lack of control: *"I wouldn't have the patience to really learn it"* (P2, novice).

The AI co-creation feature seemed to be particularly confusing to participants, many of which tried to use the feature but failed because they had not recorded themselves first, indicating a usability shortcoming in the interface. Only 7 of the participants managed to figure out how to use the feature by recording a short melody and then playing back the endless improvisation, sometimes playing on top of that improvisation. Interestingly, 5 of these participants were novices - perhaps reflecting that novices had more need for support in their creative agency than the more skilled users.

The framework of perceived agency [46] is an interesting tool for discussing the agency experienced by our participants. During the first minutes of the interaction, as the participants create the mental model of the system, they explore the technical agency. Once the participants got a sense of how the artifact responded to their actions, they proceeded to explore their creative agency by trying to make music. Some participants reported this process during the interview: *"I think you have to spend a while exploring to understand the possibilities, but you could get going pretty quickly"* (P20, competent).

5.3 Design Principle III: Meaningfulness

Many of the participants were immersed during the interaction with the Tubularium, some so much that they didn't notice a friend coming into the room, or that visitors were entering the space. In the interviews, people recalled the sounds, the lights, the space and the playfulness as some of the elements that made them feel immersed: *"Being in the darkness with the light in front of you is pretty amazing"* (P20, competent), *"the music and the lights made me be there in the moment and forget everything that was around me"*(P4, novice), *"I got very sucked in the experience"* (P27, competent). One participant also emphasized the acoustics of the space, an old church, which made them feel that the sound of the artifact was surrounding them, making them feel even more immersed.

Besides immersion, participants also described their experience as something out of their ordinary experiences, like reaching the "zone" [12]: *"When I found out a bit how it worked [...] I think I got into a zone [...] I got captivated by it"* (P15, competent). Another participant recalled it as something mystical: *"I felt I was conducting or like a wizard"*(P7, proficient). A participant also mentioned a connection with their younger self: *"It was a fun experience that woke up my inner child, mesmerising"* (P24, novice).

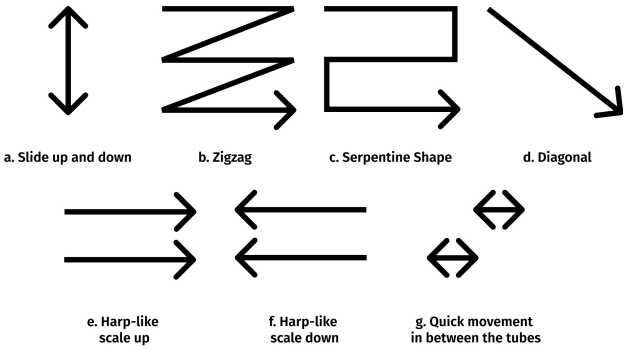

Figure 6: Schematization of the different movement patterns during the interaction

The follow-up interviews conducted one month later showed that the experience had been a memorable one, as all of the respondents were able to recall their experience with rich details: *"I remember enjoying playing because I have never seen anything like it [...] The sounds were very spacious and I thought some of them had an almost eerie character to them"* (P18, competent). All respondents stated that they had talked about it with others - mostly family and friends - and all reflected positively on the experience. Participants emphasized the multisensory qualities of the experience: *"It involved many senses. At first, the colours really caught my attention. The touch just by touching the tube, the sight with the colours that change, and then the sound. It was a great experience..."*(P4, novice). They also recalled the environment and their feelings while interacting, and highlighted the aesthetic qualities. One proficient participant shared that the interaction had inspired them to go home and make music - demonstrating that the experience had been inspiring not just for novices but also more proficient users.

6 Discussion

The test participants' interactions with the Tubularium demonstrated that the design inspired them to use their bodies in many different ways, uncovering patterns in the touches, movements, and relationships.

Some participants were gently tapping the tubes, almost as if they were caressing them, making the notes stretch in time. These participants were often exploring dreamy sounds, having a meditative experience: *"It was all super pleasant to all the senses [...] It was meditative "*(P4, novice). On the other extreme, we found participants who were hitting the tubes, making impact sounds when touching them. The touches in this case were short and rhythmic and were often used with more electronic sounds.

We identified seven main patterns of hand movements, schematized with arrows in Figure 6. Some participants were sliding up

and down the tubes to uncover the octaves (a), or sliding horizontally, exploring the scales in patterns that went zigzag (b), serpentine (c), or diagonal (d). In later stages, once the participants had already built their mental model, we saw harp-like horizontal movements with both hands (e, f), as well as small movements in the spaces between the tubes (g).

The participant's movements also seemed to reflect the intimacy intended in the design. All of the participants positioned themselves only a few centimeters away from the artifact, keeping their bodies close to the Tubularium's body. For those who participated in groups, the relationship between the members was manifested in the relationship they established with the artifact. For instance, one couple decided to play together by dividing the octaves which made their arms intertwine constantly as they were moving up and down the scale, resulting in an intimate interaction with the artifact and each other.

Whilst most of the participants interacted with their hands, some went on to use more parts of their bodies. We observed participants stretching their arms across the artifact to try and touch as many tubes as they could. One participant even used their face to get to touch one more tube. We also noted how the participants used their bodies in other ways: For instance, many participants followed the rhythm by tapping their feet on the floor or by clicking their fingers. Some participants also tried to imitate the sounds with their voices. Others gently moved parts of their bodies along with the music, and a few participants threw themselves fully into dancing.

The broad diversity of ways that participants engaged their bodies in interaction with the Tubularium offers an encouraging validation of the design approach outlined in this paper, and indicates a promising direction for future work in designing novel, human-size musicking artifacts for non-musicians.

7 Ethical Statement

This work was done following the university's policies and did not require formal ethical approval. All participants in the study signed a consent form in accordance with the General Data Protection Regulation (GDPR). Participants were offered a voucher for a non-alcoholic beverage as an appreciation token for their participation.

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