PLAY-MAKE-BELIEVE: DISCOVERING THE MUSICAL VALUES INSCRIBED INTO DIGITAL INSTRUMENTS

GIACOMO LEPRI

PLAY-MAKE-BELIEVE: DISCOVERING THE MUSICAL VALUES INSCRIBED INTO DIGITAL INSTRUMENTS

GIACOMO LEPRI

SUPERVISOR:
Prof. Andrew McPherson

EXAMINERS:
Prof. Michael Gurevich & Prof. Jonathan Impett

Submitted in partial fulfilment of the requirements of the
University of London Degree of Doctor of Philosophy
School of Electronic Engineering and Computer Science
Media and Arts Technology Programme - Centre for Doctoral Training
Queen Mary University of London
March 2022

We struggle to make research into interfaces and interactions,
but a musician only has to pick a new instrument...

—- *821 words and 20 images*,
Joel Ryan and Kristina Andersen, 2017

ABSTRACT

Artists and technologists working with digital musical instruments (DMIs) draw influence from diverse disciplines, tools and perspectives. Musical artefacts are shaped by aesthetic values as much as research concerns and design methods. These elements might vary considerably, depending on the specific community of practice and context out of which a given music technology emerges. Digital tools themselves draw on technical knowledge which is built around cultural assumptions and musical expectations.

The working hypothesis behind this dissertation is that, while assembling an instrument, music makers are engaged in a complex negotiation comprising the values and representations inherited from particular socio-cultural environments and the patterns suggested by the digital tools and materials at hand. This research explores some of the modalities through which musical ideas are inscribed in and mediated by musical interfaces.

Three empirical investigations are introduced. The first outlines a value discovery exercise exploring the breadth of perspectives musicians active in different contexts might have while speculating on the design of not-yet existing musical instruments. The second considers a selection of digital tools, examining the musical notions they promote and how these influence the composition of sonic interactions. The third reports a set of cheerful and open-ended design explorations conceived to elicit and make manifest highly personal design knowledge and visions. Finally, an autobiographical account on the making of a digital artwork is presented to situate the insights emerged from these investigations and illustrate how they might support DMI practices and their assessment.

The research advances a holistic, playful and yet critical approach to the study of new musical interfaces and, more generally, on the development of technology for creativity and the arts. Rather than jumping straight into the design of new musical interactions, this dissertation takes a step back to ponder some of the socio-material synergies and conditions that tacitly orient technological practices. This thesis offers a set of suggestions to discover and interpret the musical import of our tools and cultural settings, and critically engage in the co-creation of DMIs.

ACKNOWLEDGEMENTS

The research described in this thesis would not have been possible without the musicians, technologists and designers that, with great enthusiasm, took part in the activities here presented. I am profoundly grateful to all of them.

My thanks go to the researchers that co-organised the *10.000 Musical Instruments* workshop: Antonella Nonnis, Pete Bennett, Kristina Andersen, Paul Stapleton, Tom Mudd, Sam Topley, Andrew McPherson and John Bowers. Their support, creativity and critical mindset were essential for the organisation and accomplishment of the event.

I also warmly thank the wonderful team that made the *Unuseless Music Design* hackathon possible: Hannah Perner-Wilson, John Bowers, Jonathan Winfield, Angela McArthur, Sophie Skach, Charlotte Nordmoen, Andrea Guidi, Jacob Harrison, Robert Jack, Andrew McPherson, Antonella Nonnis, Lia Mice, Adan L. Benito and Nick Bryan-Kinns. I particularly, thanks to Hannah Perner-Wilson and John Bowers for mentoring the hackathon in a sublime fashion and providing valuable reflections that helped to shape the notion of *absurd making* outlined in this dissertation.

My gratitude goes to the Doctoral Training Centre for Media and Arts Technology (MAT) which founded this PhD. Thanks to all the staff members and the many students that, over the years, contributed in fostering a truly inspiring research environment. Particular thanks goes to the MAT director Nick Bryan-Kinns and programme manager Jonathan Winfield for their supportive, flexible and open-minded attitude.

It has been a great pleasure to work within the Centre for Digital Music (C4DM) at Queen Mary University of London. Specifically, I have been extremely lucky to be part of the Augmented Instrument Laboratory, a group that combines a great variety of research approaches and perspectives. I am particularly thankful for our regular group conversations as they were for me precious moments of reflection and learning. Out of this amazing group of people, I wish to mention Fabio Morreale which, besides working on the *Cembalo Scrivano .2*, helped me to critically navigate the Human-Computer Interaction world. Also, my thanks to the Bela team for their endless patience and constant support.

I will never thank enough Andrew McPherson that has been, without a doubt, the best supervisor I could ever had. Andrew's inquisitive mindset and critical questions were precious gifts that strengthened this work in all its aspects. Andrew's generosity and availability set the basis for a highly motivating and inspiring collaboration and his many contributions to this research were extensive and essential.

Thanks to Kristina Andersen whose work provided the foundations for this research. Thanks for the seeds she put in my head during my MMus and for the valuable conversations we had during the last five years. Also thanks to Riccardo Dapelo and Roberto Doati, for the many insightful comments and suggestions they offered every time I ask for advice.

Thanks to the many friends and colleagues that I have not mentioned, which, in one way or another, supported my work. This research has been a shared endeavour to which many people contributed. A hug full of gratefulness to Antonella Nonnis, Antonio Daniele and Sebastian Ruiz with whom I shared every single PhD step. Their love and joy have been crucial during the years and softened this arduous journey.

Un grazie pieno di gioia alla mia famiglia: Betta, Carlo, Gemma, Carmen e Olli. Per l'amore incondizionato, il sostegno costante e la pazienza infinita. Siete il dono piu' bello ed i testimoni piu' importanti. Senza di voi nulla di cio' sarebbe stato.

Un gracias mas a Carmen, mi feliz compañera de viaje.

DECLARATION

I, Giacomo Lepri, confirm that the research included within this thesis is my own work or that where it has been carried out in collaboration with, or supported by others, that this is duly acknowledged below and my contribution indicated. Previously published material is also acknowledged below.

I attest that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge break any UK law, infringe any third party's copyright or other Intellectual Property Right, or contain any confidential material.

I accept that the College has the right to use plagiarism detection software to check the electronic version of the thesis.

I confirm that this thesis has not been previously submitted for the award of a degree by this or any other university.

The copyright of this thesis rests with the author and no quotation from it or information derived from it may be published without the prior written consent of the author.

Date: April 14, 2023

Giacomo Lepri

COVID19 DISRUPTION

The COVID-19 pandemic marginally affected the work presented in this research. Specifically, I had to stop the data collection for the study presented in Chapter 4 earlier than expected because of lockdown restrictions and safety concerns. Our plans were to involve around 20 participants and we could only recruit 14.

The first four months of lockdown were particularly challenging. During that period my productivity and focus abilities considerably decreased due to work re-organisation, social isolation as well as the disruptive change of routines and the anxiety related to the uncertainty of future scenarios. Furthermore, I locked down in a very small apartment working on personal laptop without proper office facilities – at that time I was busy with data analysis work and writing of a journal article. Due to this and to the reduced amount of physical activity, I got an acute posture-related backache that required two months of treatments to fade out.

PUBLICATIONS

Some ideas and figures have appeared previously in the following publications:

- Giacomo Lepri and Andrew McPherson. 2018. "Mirroring the Past, from Typewriting to Interactive Art: an Approach to the Re-design of a Vintage Technology" *Proceedings of the International Conference on New Interfaces for Musical Expression*.
- Giacomo Lepri and Andrew McPherson. 2019. "Making Up Instruments: Design Fiction for Value Discovery in Communities of Musical Practice" *Proceedings of the Designing Interactive Systems Conference*
- Giacomo Lepri and Andrew McPherson. 2019. "Fictional Instruments, Real Values: Discovering Musical Backgrounds with Non-Functional Prototypes" *Proceedings of the International Conference on New Interfaces for Musical Expression*.
- Visda Goudarzi, Artemi Maria Gioti, Giacomo Lepri and Fabio Morreale. 2019. "Exploring Participatory Sound Art" *Proceedings of the International Computer Music Conference*.
- Giacomo Lepri, Andrew McPherson and John Bowers. 2020. "Useless, not Worthless: Absurd Making as Critical Practice" *Proceedings of the Designing Interactive Systems Conference* – Honorable Mention Award.
- Andrew McPherson and Giacomo Lepri. 2020. "Beholden to Our Tools: Negotiating with Technology while Sketching Digital Instruments" *Proceedings of the International Conference on New Interfaces for Musical Expression*.
- Giacomo Lepri. 2020. "Sonification as Negotiation - Learning from Translation Studies" *Proceedings of the Sound and Music Computing Conference*.
- Giacomo Lepri, Andrew McPherson, Antonella Nonnis, Pete Bennett, Kristina Andersen, Paul Stapleton, Tom Mudd, Sam Topley and John Bowers. 2021. "Play Make Believe: Exploring Design Fiction and Absurd Making for Critical NIME Design" *Accepted workshop proposal at the International Conference on New Interfaces for Musical Expression* – Best Conference Workshop Award.
- Giacomo Lepri and Andrew McPherson. Forthcoming. "Embrace the Weirdness: Negotiating Values Inscribed into Music Technology" *Computer Music Journal*.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

CoP Communities of Practice

CS Cembalo Scrivano

DMI Digital Musical Instrument

DAW Digital Audio Workstation

FSR Force Sensing Resistor

HCI Human Computer Interaction

ICAD International Community for Auditory Display

ICMC International Computer Music Conference

LED Light Emitting Diode

MIDI Musical Instrument Digital Interface

NIME New Interfaces for Musical Expression

OSC Open Sound Control

RtD Research through Design

STS Science and Technology Studies

VSD Value Sensitive Design

1

INTRODUCTION

"The skeletons in our closets are most likely old computers"
Joseph Auner – [26]

Researchers active in disparate domains, such as anthropology and Human Computer Interaction (HCI), provide compelling perspectives on craft and design that celebrate the intimate, physical and tacit factors linked to these practices [182, 196]. Such views emphasise the implicit knowledge we develop while interacting with tools and materials, which are often understood as "living" components actively influencing making processes [110, 195].

One might argue that such reflections bring design closer to music. The magical intertwining between bodies, instruments and sounds is indeed hard to frame based on a symbolic, rational and language-oriented stance [360]. Writing about music is like dancing about architecture, as the expression goes. Musicians soon understand that practice is key, as noted by Michel Waisvisz "I discovered long ago that it works 'just to do things' in music" [ibid. p 124]. Aware of this, music technologists often aim to examine new instruments making explicit the embodied and tacit knowledge acquired while designing and interacting with musical artefacts [125, 158, 384].

Alongside our sensory-motor capabilities, the engagement with musical objects [1] requires the employment of cognitive, emotional and intellectual resources which allows us to engage with the *broader context*, shaping our actions and delineating musical intentions and significations. Music, as any other embodied conduct, is *in situation*: grounded socially and culturally as well as cognitively and experientially [116].

The social contexts in which instruments are employed then contribute to shape their *cultural form* [184]. Such form, as much as physical affordances and constrains, significantly pre-configures the perception and interpretation of musical tools [163].

1 The term *musical object* has here a broad and inclusive connotation – e.g. a score is an object as much as an instrument.

This socio-cultural mechanism certainly also takes place within those sectors concerned with the development and use of new instruments. Music technologists and researchers might inherit and promote cultural attitudes from their disciplinary contexts [153] and pursuit a great variety of different ambitions, ranging from technical optimisation to philosophical thought. Instrument designers might chase their individual musical visions through their creative work [90] and be the primary "users" of the technology they develop [270]. Alternatively, they might target particular communities of musical practices [251] or exploit digital instruments to investigate a great variety of issues linked to music cognition, performance and interactions [223].

The examination of the complex network of situated significances grounding the work of music technologists has been traditionally entrusted to musicologists [61, 344] and, within the domains of musical interaction research, practitioners rarely consider their own musical assumptions and socio-political values [45, 271, 170]. Such tendency can be partially related to the influence that techno-scientific thought has on technology-driven domains in which sectorisation and specialisation exempt researchers from a reflection that goes beyond the insularity of their object of study [136].

This situation then implies that, in music technology contexts, what is *tacit* are also the contingent representations, beliefs and perspectives that practitioners mobilise while working with musical interfaces. As a result, new musical tools often carry unstated cultural assumptions which, if not made explicit, risk to undermine related academic, technological and artistic practices.

The thesis therefore advances a few strategies for the acknowledgment of contextual concerns and expectations in order to support the critical practices of artists and technologists engaged with the design of musical interactions. These strategies are discussed in detail to provide practical suggestions that, beside orienting design choices, might help to address targeted communities and clarify the intended goals and uses of a particular musical artefact.

How can we make these values and expectations visible to the researcher's eyes, whether they are subjective or culturally situated? How to recognise the musical notions and assumptions inscribed into a given digital musical tool? How can we acknowledge the spectrum of values and concerns characterising the musical communities we are part of? How can we approach these questions through creative, practice-based and design-oriented methods that resonate with the routines, mindsets and sensitivities of music technologists? These are some of the main concerns

behind the investigations here collected.

The main contributions of this research are a set of methodological suggestions (or heuristics) for NIME (New Interfaces for Musical Expression) design. These open-ended and critical inputs draw from different practices and mindsets linked to disparate contexts, including design, computer music, the arts and social sciences. On one hand, the dissertation aims to provide a few conceptual tools to better understand the complex processes through which shared musical knowledge travels across communities and technologies. On the other, it explores a set of practical approaches for the discovery and interpretation of the values inscribed in and mediated by new digital instruments. Based on this it is possible to affirm that this dissertation stands at the intersection of NIME design methodology and critical NIME thinking, with multiple roots in neighbouring fields.

In particular this research identifies and examines three viable factors often influencing the work of music technology practitioners: the cultural notions inherited from cultural settings and communities, the patterns of use promoted by digital tools and materials, and the individual visions, intuitions and judgments introduced by each maker. By considering how these elements are in a relationship of reciprocal determination, this dissertation brings to the forefront some of the socio-technical implications linked to electronic music practices and technology research.

The works here collected then offer a view on the modalities through which, in the contexts of computer-mediated musical creation and performance, specific ideas and practices become more "successful" or "contagious" than others, and how they influence design processes, physical interactions and musical aesthetics. This is a quest that, on one hand, scouts the cultural ground upon which musical ideas are able to flourish, and, on the other, examines digital instruments as contributing to shape their environments as well as the specific communities and cultures from which they arisen.

Overall, this work highlights the importance of cultural awareness and value rationality for the design of interactive systems within and beyond the musical domain. In the society of technological innovation – in which new media are destined to rapidly become old – it seems crucial to develop our abilities for the critical scrutiny of the origins and evolution of our instruments. By showing that music technologists often transfer into musical artefacts pre-existing beliefs and assumptions, this research question the notion of "new" (intended as better, more

powerful and efficient), which might be then replaced by concepts such as reinterpreted, reused and re-generated.

1.1 SCOPE OF THE THESIS

This research moves from a rather simple observation: in the era of digital reproduction almost every aspect of our musical experience is mediated by, or delegated to, technological artefacts. On one hand, the work here presented then sets with the idea that one of the main challenges posed by contemporary musical work lies precisely in recognising and assessing the ways technology influences our practices. On the other, as our techno-scientific capabilities of altering the material world exponentially increase, it seems crucial to develop contributions that support researchers to reflect on the social contexts they operate in as well as on the consequences of their practices beyond specialised and technology-focused investigations [170].

This dissertation examines the design of music technology as a complex process, entailing the materialisation of knowledge that is at once cultural and technical. Digital music tools are therefore treated as multifaceted assemblages [345], emerging out of intricate socio-technical and temporal relationships [62]. This thesis then explores the interplay between culture, design tools and musical practices, considering technology as both caused by and causing human action.

The works here presented are mostly in dialogue with the investigations and literature coming from the New Interfaces for Musical Expression (NIME), Sound and Music Computing (SMC) and Human Computer Interaction (HCI) domains – this also due to the research expectations of the department in which this thesis has been developed. This purposefully selective outlook inevitably narrows down the scope of this dissertation, excluding from the discussion relevant contributions linked to domains such as composition, musicology and performance studies.

According to this perspective, the focus is on the critical study of Digital Musical Instruments (DMI) adopting the term, its formulation and conceptual understanding from the NIME tradition. In the context of this thesis DMIs are essentially understood as technologies for music performance which combine a physical interface, which senses the performer' s gestures, and a digital component that translates the incoming data into sonic outputs.

Throughout the thesis the terms "musical interface", "novel musical instrument", "interactive musical system" and "digital musical artefact" are used as

synonyms of DMI, somehow overlooking the fact that these expressions can be related to different bodies of theories and imply diverse artistic connotations. Also the term *digital musical tool* is used as an equivalent of the DMI acronymous, with the exception of chapter Chapter 4, where it indicates the various components (i.e. the building blocks) constituting a DMI – such as Pure Data (Pd) and SuperCollider audio programming languages or basic hardware sensors (e.g. knobs and buttons).

More specifically, in Chapter 4 the expression *digital musical tool* is used to refer to hardware and software elements which can be considered as well defined components that a designer manipulates and integrates into a given DMI. Pd, buttons and knobs are then examined as mature and well-defined building blocks, emerging from specific socio-technical genealogies, mobilising particular cultures of use as well as shared expectations and contextual meanings. Based on this outlook, in Chapter 4 DMIs are discussed as assemblages, indirectly alluding to Latour's work, thus viewing them as composite objects emerging from the intersection of many socio-technical factors.

Music technology practitioners draw influence from diverse disciplines, expertise and cultural perspectives. Alongside operational and technical works, holistic and critical research help us to better frame the overall implications of our musical practices. Such works comprise gender and class studies [377, 66], discussions on the diversity of methods and contributions [305, 231] as well as inquiries on ethics and inclusion [271, 131].

As the music technology community gradually expands its "ways of knowing" [193], we begin to appreciate how DMI practices are shaped by cultural values as much as research concerns and methods [250] – factors that might considerably vary depending on the particular context in which the work is carried [153].

Researchers concerned with the design of musical artefacts and interactions then often challenge the role of instruments in creative practice as well as the methods adopted for the development of musical interfaces in academic contexts – see amongst others [70, 156, 148, 170]. This thesis relates to these research trends sharing their overall sensitivities and concerns.

In recent years, HCI has seen a flourishing of viewpoints and methods as diverse fields have been brought into contact with its research practice [287]. Researchers are increasingly engaged with critical discourses, mediating perspectives coming from the arts [103], social sciences [209] and philosophy [31]. These expansions

and diversifications are often described in relation to different "waves" in HCI research, each supporting increasing levels of intellectual diversity [59, 130].

Within this framework, the research here introduced strongly relates to the critical and contingent attitudes that characterise Research through Design (RtD) [140, 385]. In particular, the studies reported combine fictional, speculative and ludic design approaches [118, 54, 361] which allowed for both engaging participants in playful design exercises and unveil the rich and composite nature of the resulting musical artefacts [141, 321].

The rationale developed in this thesis also exploits some ideas coming from media studies, philosophy of technology and Science and Technology Studies (STS). Most notably, the notions of *inscription* and *remediation* is an important conceptual tool here exploited to frame the socio-technical implications of DMIs [256, 60].

Furthermore, the concept of *negotiation* is adopted as a powerful key for the interpretation of the relations between human beings and their artefacts. Considering new musical instruments through the perspective of negotiation allows us to acknowledge the constellation of cultural, technological and individual elements which intervene in the making and use of a DMI [62]. Based on this attitude we then expand the technical notion of *design* towards that of *assemblage* [65].

From a more general viewpoint, this thesis draws inspiration by various philosophical works often labelled as *posthuman* or *new materialism*. In particular, entanglement theories (as Frauenberger calls them [130]) such as Latour's Actor-Network Theory [217], Ihde's Post-Phenomenology [308] and Barad's Agential Realism [28] indirectly influenced our work as they often are pivotal references for many of the HCI and NIME research this dissertation is in conversation with.

Finally, the theoretical considerations and methodological suggestions proposed in this thesis are mainly concerned with the ideation and design of new musical interfaces in academic research contexts. This research then aims to speak primarily to those practitioners that, while making art and technology, aim to produce and share research outcomes that might be relevant for other music technologists – e.g. to say something about the development and use a of particular music technology within a socio-cultural setting. In particular, the considerations introduced in Chapter 7 highlight the importance of value discovery to both design instruments that target specific music communities and support the emergence of creative and unconventional traits in music technology contexts.

On a different extent, the contributions introduced in the following chapters have relevance beyond DMI design. First, researchers and technologists involved in HCI and interaction design might benefit from the value discovery strategies explored in this research to situate their work and better understand users' needs and problems, acknowledging their socio-cultural affiliations and technological views. Second, the methodological suggestions introduced in this dissertation might be adopted in educational contexts to help (music) technology students to bring their own values to the fore, better understand the values embedded into the technologies they use and develop their critical perspective – see Chapter 7 for a discussion on the pedagogical implications of our work.

This doctoral research moves from a perspective that privileges artistic creation as the ultimate goal of music technology practices. The work here articulated embraces critical and humanistic views and it often examines the design and use of new interfaces through musical, compositional and performative concerns. This attitude is grounded in the assumption that future achievements might "solve" some technical issues, but the artistic dilemmas and stimuli posed by digital instruments are likely to be with us for a long time.

Based on this attitude, the studies here presented explore the design of DMI through open-ended and creative approaches, inspired by artistic and music practices. The playful, yet serious, approaches for critical making then turned out to be particularly suitable to both explore the musical expertise and sensibilities of musicians and engage with rich, complex and often amusing design outcomes. As Perry Cook pointed out "musical interface construction proceeds as more art than science, and possibly this is the only way it can be done" [97, p. 6].

1.2 HOW DID I END UP HERE

Before proceeding any further it might be helpful to provide some clues on how this thesis came about. The intention is to introduce some of the reflections behind this research, also including more personal insights related to my journey within the domains of music and technology.

My musical adventures began with the study of piano and percussion and a focus on the Jazz, Afro-Cuban and Brazilian traditions. Since my teens, I also had the chance to participate in a variety of projects related to the production and performance of folk and songwriting music. The passion for improvisation led me to explore more experimental practices related to contemporary jazz and I soon

become interested in the so-called *non-idiomatic* or *free improvisation*. Thanks to these musical interests, I soon discovered those musical practices in which acoustic instruments are combined with *live electronics* in improvisational settings. My dedication to the technologies of music still feeds back to such fascinations and yearnings.

Driven by a spirit of curiosity, during the last years, my artistic work has been exploring the fields of electroacoustic composition and improvisation, sonic interaction design and sound art. This journey has been so far exciting and precious – at least for the many inspiring people I had the chance to meet, and the many things I learned from them and their artwork.

The issues addressed in this thesis partly emerged from a series of reflections confronting contemporary electronic music practices, their origins and academic affiliations. Overall, we might agree that outstanding artworks are rare and they often do not need much explanation to be appreciated. Nevertheless, there is great value in any creative act, from the pupil's first musical attempts to the latests electroacoustic piece made by a senior and renowned composer.

However, despite the formal level of expertise and status of music technology practitioners, it is often possible to identify a set of lazy attitudes and routines, which risk to flatten the creative work on and with sound. Music technology teachers will be familiar with the tendency of beginning students to create musical interfaces which often (dis)play similar aesthetics and interactions (e.g. theremin-like or keyboard based instruments) [191]. Attendees of electroacoustic and live electronics concerts will likewise encounter a recognisable prevailing (though by no means universal) aesthetic, often including the same audio effects, textured noises or manipulated samples [20].

This thesis explores the degrees to which this clustering is due to cultural dynamics (e.g. aesthetic-pedagogical habits [249]) or to the standardisation and spread of specific tools within the interactive art and music technology communities [343]. On one hand, the opportunities offered by new tools might be subordinated to pre-existing ideas which musicians culturally inherit [115]. On the other, practitioners might fall for the latest fashionable tool (whether actually new or revived) and end up composing what the technology makes easier or more obvious [259].

While navigating the music technology fields, I also had the opportunity to get in close touch with researchers affiliated to computer science and engineering

departments – as an obvious example, this doctoral research has been carried at an engineering school. Once again, these encounters has been valuable and formative as I could learn a lot from colleagues and their enthusiastic and clever approaches towards technology research.

An epistemological prerogative of these contexts is that research contributions are often meant to be evidence-based and peer-reviewed. Although many aspects of such methodological commitment have been regarded as "socially constructed" [42], its demand of rigour and concreteness forces us to carefully ground our musical practices and contributions. From this viewpoint, technological advancements constantly open up new creative possibilities, making the field of music technology an exciting, generative and dynamic research context.

Understandably, engineers and computer scientists are primarily interested in technological innovation. As a matter of fact, technological research and development is characterised by an intense fast-pace. Tools and techniques which once stood out for their novelty and performance rapidly fall into disuse, supplanted by newer and ostensibly improved technologies [50]. The techno-scientific work is indeed mainly organised around a *short-term* notion of time: the recent past (the latest up-to-date technology) and the immediate future (the next legitimate advancement). Scientific formulations are inherently renewable as a new hypothesis, if empirically validated, can discard previous principles and becomes the new knowledge. Accordingly, new implementations are then "in vogue" until a "better" technology makes them obsolete.

Throughout the last half of the twentieth century, the ideas of linear time and progress have been challenged by many postmodern theories, which extend well beyond the scope of this thesis. However, often based on a boundless idea of socio-economic growth, the narrative of the "perpetual advancement" still permeates many aspects of the western culture [214] – including music technology development. Although within the creative sectors technological innovation is often celebrated, one might argue that the innovation-to-obsolescence circle places artists in an always-new-present where they have always less time to cope with constant, fast and radical changes. Musicians might agree with me in finding such circumstances rather problematic [2].

Music technology researchers have indeed argued that the development of intimate and embodied relationships with DMIs can be essentially achieved by engaging in long-term artistic practice – e.g. [349, 124]. According to this view, the

2 See the famous example of Jean-Claude Risset who refused to update the equipment used in his studio [314]

time we spend with our instruments becomes a crucial element for the emergence of nuanced, complex and unique music performances and aesthetics.

More importantly, the rapid loss of technological innovations to obsolescence makes particularly difficult to identify the origin and evolution of an artefact, including the cultural context from which it first emerged. While prioritising technological innovation, we risk to solely focus on DMI design and evaluation without explicit consideration on the socio-cultural, aesthetic grounds that made possible the manifestation of a given musical interface. The risk is then to be able to explain everything about the particular without understanding anything about the context. As Pascal wrote a few centuries ago:

> "All that exists [..] is both cause and effect, dependent and supporting, mediate and immediate, and all is held together by a natural though imperceptible bond, which unites things most distant and most different. I hold it impossible to know the parts without knowing the whole, or to know the whole without knowing the parts in detail" [291, p. 23].

The brief personal excursus presented in this section ultimately aims to make more explicit my own values (i.e. where I am coming from) and clarify the concerns that motivated this research. Like many music technologists I found myself wearing different hats depending on the tasks and contexts I address in my everyday work. This dissertation can be ascribed to two main perspectives which privilege different values.

On one hand, as designer and technologist, I set with the goal of revealing shared assumptions and technological habits in order to critically engage the development and use of new music technology. From this perspective, I consider value discovery as the pivotal element of the research, and the strategies explored to expose tacit knowledge, and translate them into operational choices, are strongly inspired by design, HCI and ethnographic methods.

On the other, as an artist, I often try to resist my own banality and I am attentive to the construction of strategies that form an impediment to the reproduction of musical stereotypes and latent technological routines. These values and concerns prompted the retrieval of more disruptive techniques linked to the arts. These techniques are then suggested to abandon conventional ideas and design patterns in order to facilitate the emergence of creative traits in NIME research. According to this mindset, I explore value discovery as the first necessary step of a "defamiliarization" process which might allow to get access to new forms of artistic expression.

Throughout the thesis these two voices alternatively emerge, and the implicit "switching" between them might generate a tension in research objectives as different chapters aim at slightly different things. For instance, Chapter 3 and 4 mainly advance an HCI and ethnographic outlook to increase technological awareness and properly address the needs and priorities of different musicians. Chapter 5 and 6 instead exploit value discovery in view of more creative and artistic goals.

A further element of ambiguity, sometimes emerging throughout the thesis, relates the idea of "newness". My journey in the music tech word led me to develop a rather skeptical attitude towards technological novelty *per se*. Especially in engineering contexts, innovation tends to become a leading narrative that overshadows many concurring factors and implications linked to technology design (e.g. ethical, economical and political). Simultaneously, I am attracted to the notion of artistic exploration and creation where elements of novelty play crucial roles for the emergence of musical inventions. I attempt to soften this friction by conditioning the idea of newness with notions of reuse and repurpose, also drawing on theories coming from philosophy of technology, media studies and social sciences.

Departing from these design ethos, this thesis aims to provide a clear account on how, besides technical expertise, the development of a music technology entails the materialisation of purposes and assumptions. The empirical work here presented then explores a set of strategies for the discovery of situated musical values emerging from specific communities and identifiable in the tools and artefacts these contexts produce.

This research is then concerned with the ways unstated cultural assumptions influence design choice as well as instrument's uses and interpretations. A culturally-aware approach to NIME research is then proposed, which aims to discover and embrace underlying musical values, whether they derive from a target musical community, the tools and materials used to craft an interface or the researchers themselves.

1.3 RESEARCH QUESTIONS

The key research questions I ask in this research are:

1. *How can we discover shared values and assumptions produced by different communities of practice in relation to new instruments?*

   In particular I ask:

   - In what ways does the involvement with a community of musical practice shape the understanding of musical interactions?
   - Given a novel musical instrument, to what extent can the musical background of its maker be identified?
   - How do makers' musical background influence the design and interpretation of new DMI?

2. *How do digital music tools influence the design of novel musical interfaces?*

   In particular I ask:

   - How can we identify the cultural load carried by a particular music tool?
   - How do the values embedded into musical tools condition new musical interactions?
   - How do musicians react to the suggestions offered by technology?

3. *How can we unveil the personal design knowledge and views brought in by practitioners engaged in the DMI practices?*

   Particular questions I address are:

   - How can we make manifest subjective intuitions and narratives for the ideation and development of musical interfaces?
   - How can playful and open-ended design activities be exploited for the discovery of personal design perspectives?
   - How can we explore unconventional, critical and diversified visions on NIME practices beyond the paradigms imposed by current music technology?

This dissertation examines three viable factors often influencing the work of music technologists: the shared values linked to diverse communities of musical practice, the musical patterns promoted by design tools and the personal visions through which practitioners handle the assemblage of digital musical artefacts. The cultural, technical and subjective influences considered in this research are then shown to be highly co-dependent and decisive for the the inscription of knowledge into musical interfaces. Based on this outline, the structure of this thesis is as follows:

Chapter 2 gathers the theoretical frameworks supporting the research investigations presented in this dissertation. It is split into three sections: the first discusses a set of critical music technology works, highlighting some of the techno-musical intricacies characterising the NIME research contexts; the second introduces relevant concepts and theories drawing on philosophy of technology and Science and Technology Studies (STS); the third considers considers various works from social sciences, HCI and the arts which frame design as a situated practice that simultaneously embodies contingent knowledge and contributes to the social construction of reality.

In Chapter 3 I detail two studies focusing on the discovery of shared musical values within different musical contexts based on design of fictional musical instruments. First, I introduce a workshop in which musicians active in different musical contexts are invited to imagine and sketch not-yet existing music instruments "as if by magic". Second, I report on an online survey in which music technologists were asked to speculate on the background of the musicians who designed the fictional instruments. This research allowed us to directly engage with a broad set of perspectives and attitudes for the interpretation of musical interactions which were largely shared within and across musicians affiliated to specific communities of musical practice.

In Chapter 4 I describe a compositional game in which music technologists were invited to create simple DMIs using common sensors and the Pure Data programming language (Pd). This research provides an antithesis to the speculative and non-functional approach previously introduced, focusing on specific hardware and software technologies and examining how they influence the making of musical interfaces. The outcomes of this sonic interaction design exercise are then

discussed in light of both makers' techno-musical backgrounds and the musical interactions promoted by the tools and materials provided.

The work introduced in Chapter 5 focuses instead on the individual perspectives brought in by practitioners engaged in the design of digital musical instruments. I present two activities organised around the themes of absurd musical interfaces, questionable sonic interactions and unworkable music designs. In the context of this research, the "subjective factor" then relates to the individual understandings of the "musical absurd" that often revealed musicians' concerns and priorities. In particular, these research gave us the opportunity to elicit and make manifest highly subjective visions that both set and critique what practitioners perceived as ordinary and familiar in music technology contexts.

Chapter 6 presents a practice-based and self-reflexive account on the *Cembalo Scrivano*, an interactive audio-visual installation I developed during the course of my PhD. The discussion aims to highlight how, while considering in detail a single and situated designs, cultural, technical and subjective factors often result inherently interdependent and hardly separable. Overall, the chapter provides a set of open-ended reflections that further clarify how the questions posed in this dissertation might support the critical scrutiny and assessment of DMI practices.

Finally, the discussion introduced in Chapter 7 offers a few conceptual and methodological suggestions that might inform our critical practices based on findings gained through the theoretical and empirical work presented in previous chapters. These methodological and analytical reflections focus on the playful discovery of the socio-material grounds in which DMIs are rooted as well as the subjective negotiation of such cultural and technological factors.

1.5 METHODS

This research explores a set of approaches for the discovery of the values and representations inscribed in digital music tools. Design processes are then examined as shaped by pre-existing musical notions and musical interfaces are scrutinised for their musical predisposition over particular compositional and performative conducts.

The works introduced in this dissertation combine a set of creative and playful approaches for the ideation and development of musical interfaces which promote rich and critical reflections through disruptive and hands-on design activities [71]. Within this context, the research draws on a set of critical methods for the ac-

knowledgement of culturally situated values such as Feminist HCI [32], Research through Design [69] and Value discovery [219].

The studies introduced in Chapter 3 exploit design fiction methods to explore the different modalities through which musicians active in different contexts envision not-yet existing music instruments [14]. The reflections and speculations provided by the musicians involved in the research were then captured through a mix of qualitative methods, including focus groups, interviews and semi-structured surveys [77], and analysed following a thematic approach [311] based on the development of data-driven codebooks [105].

Drawing on these approaches, the compositional game introduced in Chapter 4 considers the design of sonic interactions and their "think-aloud" demonstrations. Our method then evokes the expertise and knowledge of music technologists on the use of musical tools as well as their abilities to perform with them [149].

The pointless musical creations examined in Chapter 5 instead relate to different thought-provoking design strategies for the generation of critical and personal design knowledge [109, 374, 71]. Strange, fragile, cheerful and sometimes naive musical artefacts are then exploited to produce a kind of design vision hooked to the individual makers and embedded into the narratives they participate in [14, 55, 357].

Chapter 6 instead takes inspiration from HCI first-person [237, 181, 279] and NIME practice-based methods [203, 154, 90] to describe the origins and evolution of a digital artwork I developed drawing on media archaeology art approaches [176, 290].

1.6 STATEMENT OF CONTRIBUTION

This research's main contribution is the exposition of a set of strategies for the discovery of values in DMI practice. This dissertation also sets the stage for value discovery research that is currently under-explored in musical instrument design, and more generally, in music technology contexts. The main contributions can be summarised as follows, in the order in which they appear in this thesis:

- The design fiction work outlined in Chapter 3 expands on Kristina Andersen's workshop [14] to query shared values and concerns brought in by participants. In particular, we detail an approach for the analysis of the work-

shop outcomes and a further speculative enquiry to better examine the cultural values inscribed into fictional instruments.

- Chapter 4 outlines an approach for the discovery of the musical patterns promoted by specific musical tools based on playful interaction design briefs.

- In Chapter 5 the notion of the "musical absurd" is suggested as a powerful tool to stimulate individuals' musical creativity, unlock unconventional musical visions and reveal critical perspectives on technology development.

- The autobiographical account reported in Chapter 6 situates the insights emerged from previous chapters in a lived experience and demonstrates how these findings can be applied to support the critical scrutiny of DMI practices.

- The discussion of Chapter 7 articulates a set of theoretical and methodological suggestions for the discovery of values and assumptions in NIME practices before committing to any particular approach to technology creation.

2

FRAMEWORKS

This chapter incorporates snippets of material from 'Mirroring the Past, from Typewriting to Interactive Art: an Approach to the Re-design of a Vintage Technology', 'Fictional Instruments, Real Values: Discovering Musical Backgrounds with Non-Functional Prototypes' and 'Beholden to Our Tools: Negotiating with Technology while Sketching Digital Instruments' by Lepri and McPherson originally published in the proceedings of the International Conference on New Interfaces for Musical Expression, NIME 2018, 2019 and 2020 [227, 228, 258]; 'Making Up Instruments: Design Fiction for Value Discovery in Communities of Musical Practice' by Lepri and McPherson and 'Absurd Making as Critical Practice' by Lepri, McPherson and Bowers, originally published in the proceedings of the Designing Interactive Systems Conference, DIS 2019 and 2020 [225, 229] and 'Embrace the Weirdness: Negotiating Values Inscribed into Music Technology' by Lepri and McPherson, currently under review, to be published in the Computer Music Journal [226].

This chapter gathers the theoretical frameworks grounding our research. We begin by surveying various NIME and music technology contributions linked to the critical scrutiny of musical interactions and related design practices. We then introduce a set of reflections on the non-neutrality of technology drawing on the fields of philosophy of technology, media theory and STS. Finally, we move to the domain of interaction design, discussing relevant HCI research concerned with socio-cultural studies and art-inspired approaches.

2.1 CRITICAL NIME RESEARCH

"I wish Bach had claimed the invention of virtual reality"
Michel Waisvisz – [360]

Along with technical expertise, the design of an instrument involves the materialisation of assumptions, musical representations and cultural values. Instrument makers then balance knowledge coming from diverse disciplines and traditions. In particular, NIME research has strong multidisciplinary implications as it draws on a variety of fields and practices, such as composition and improvisation, elec-

troacoustic music, computer science, design and engineering. Digital instruments are also examined from different viewpoints, including musicology [344], social sciences [297], cognitive science and performance studies [223].

As a result of these cross-fertilisations, a clutter of mindsets, objectives, methods, and outcomes coexist within the same field [152]. A famous account of such diversity is provided by Alexandra Supper which described in detail some of the divergences founded within the International Community for Auditory Display (ICAD) [340]. Supper then identifies "Trained Ears" and "Correlation Coefficients" cultures, associating them to distinct research concerns linked to particular disciplinary backgrounds.

Similarly, the strong interdisciplinary nature of NIME often implies that "the background expectations of one field are not met by research whose approach derives from another" [153]. In an attempt to address this and related issues, the NIME community is currently engaged with a series of self-critical debates. To name a few: the conundrum of musical expression [113, 156], the diversity in research approaches [153, 148, 268] and the appreciation of different sub-communities and their identities [250, 270] as well as discussions of representation and authorship [377].

Within the domains of musical interactions and instrument design, a small but growing body of work engages with the political implications of technology ideation and development. Examples of such research include the reflections by Tomás [346] on the prevailing tendencies for musical creation with digital interfaces and their significance to contemporary consumerism.

NIME practitioners are proposing direct actions to deal with political issues linked to NIME research. Morreale et al. [271] examine instruments as cultural artefacts which re-produce political discourses, identifying a set of directions to engage with socio-cultural and ethical topics within and beyond academic contexts. Bin [45] instead suggests that collective efforts are needed to improve the ways we document our work as NIME's historical record is a powerful tool for the critical examination of NIME epistemological complexities.

Drawing on Born's relational musicology, Hayes and Marquez-Borbon [170] discuss the "political and epistemological crises" within the NIME research community, arguing that certain "disciplinary and social frictions" relates to the "quantification and economisation of research" we increasingly witness in academia [p. 428]. Following Green's suggestions, Hayes and Marquez Borbon considered

Born's four planes [1] of social mediation [63], noticing that, although "there has been extensive NIME research on the micro-socialities of the first plane ... and on the second, with the various imagined public groups that engage in these activities", a few cluster of activities within NIME have engaged with the broader issues linked to the third and fourth planes identified by Born – i.e. "large-scale social, cultural, economic and political forces that provide for [music] production, reproduction or transformation" [63, p. 232].

This dissertation does not directly engage with broad sociopolitical matters that, as uncovered by the research here gathered, currently challenge our academic and musical institutions. Rather, we examine the ways in which designers and musicians active in different communities, contexts and disciplinary fields [2] might express their own values through making, and what cues an observer would then use to recognise them. Our work then aims to contribute to NIME critical discussions by outlining a few approaches for the discovery of perspectives NIME practitioners might mobilise while imagining, designing and playing new digital instruments.

2.1.1 *A techno-musical imbroglio*

Although since the advent of real-time computing proto-NIME research has been presented in venues such as the International Computer Music Conference (ICMC) and related journals (e.g. [365, 232, 86]), the first NIME workshop took place in 2001 as part of the SIGCHI conference [202].

This affiliation continued through the years and NIME gradually embraced a range of values and approaches from HCI – as noted by Bin [45], these include the "problem" of DMI "evaluation" [366, 288, 205], a view of the musician as "user" [206] and the infatuation with design frameworks and guidelines [269].

On a more general level, DMI research has drawn inspiration from the more technical ends of HCI spectrum by adopting the methodological rigour and scientific mindset that distinguishes the engineering work [380]. Furthermore, the influence of HCI on NIME might appear to have an aesthetic component, as second-

1 As summarised by Green "Born divides social aspects of music into four irreducible planes: the micro-social aspects of musical action (1st) and associated 'imagined communities' (2nd), through to larger formations, such as the ways in which music mediates relations of race, gender and class (3rd) and is bound up in political and historical currents (4th)" [148, p. 2].

2 In this respect, our research might be ascribed to Born's second plane, although our insights sometime point at wider social relations and historical courses.

wave HCI theories of information flow share a language with notions of musical expression as communication [156, 154, 274].

There remains considerable value in HCI research around musical communities whose performance practice does not explicitly involve computing. The work of Benford and colleagues is notable in this area, including ethnographic studies of Irish session musicians [37] and DJs [3] and a technology probe study involving a purely acoustic guitar accompanied by scannable digital codes [38], each of which reveal some of the underlying values of their communities. However more work remains in querying what musical communities expect from their instruments, and the role that computing might play, before committing to any particular approach to technology creation.

In highlighting the obvious and deep affinity between these two communities, we want to stress that DMI practice does not necessarily represent a neutral *aesthetic* cross-section of possible research in music and HCI. While digital music communities are sometimes criticised for being preoccupied with technical factors [156], an equal challenge is not the lack of aesthetic reflection but rather a surfeit of latent cultural assumptions.

NIME practice partly inherits from *musique concrète* and *elektronische musik* traditions. Although a full review of which is beyond the scope of this thesis, it possible to argue that postwar serialism, Cageian indeterminacy and particularly *algorithmic composition* have strongly influenced NIME research [91, 107, 123, 154].

To name one, the use of random and probability-based processes often embedded in new DMIs can be related to the work laid out by composers and researchers such as Lejaren Hiller, Gottfried Michael Koenig and Iannis Xenakis. Paul Berg thoroughly observed that the musical concepts introduced by these musicians proved to be rather resilient, and they can be found in many computer systems and workstations of the 1970s, 1980s and 1990s [39]. Such compositional approaches keep finding their way into contemporary NIME design and related musical productions.

Against this background, it is worth considering that even generic design principles of DMIs such as *mapping*, as the composition of the relationships between actions and sonic features [189], may have cultural overtones. In this case, perhaps a post-serialist tendency to organise musical events into multidimensional feature spaces which are systematically explored over time. Alternatively, mapping strategies, intended as functions that systematically describe the relations between two

given systems, often unveil a procedural and technical gaze directed towards the modelling of complex phenomena.

Such overtones become relevant in designing toolkits or participatory exercises which seek to let musicians create their own instruments [81, 280, 245]: whatever the merit of the resulting devices, it is unclear whether such exercises reveal the values of musicians not already part of the DMI community or those of NIME researchers themselves.

NIME socio-technical intricacies do not stop here. Research mindsets and applications include accessibility and special needs [131], cross cultural collaborations [76], classical and folk music practices [207, 352] sonic arts and installations [276], media studies [179] and post-colonial perspectives [350]. A full accounting of NIME values depends on a great variety of factors, such as repertoire [154], pedagogy [249] and performer skill [146].

NIME practitioners are also influenced by common places and shared representations coming from the music technology industry. For instance, within the music market, DMIs are often proposed as means for personal sense of individual achievement and creativity, effortless production, leisure, and immediate gratification [271, 262, 274]. Such narratives can be traced back to the commercialisation of first automatic musical instruments in the late eighteenth and early nineteenth centuries. Théberge [344] sharply describes how the "consumer mythology" of early pianos rolls industry relied on tropes such as personal expression, universal accessibility and immediacy, which still qualify many music technology discourses.

It is not our intention to trace all of NIME's influences. Rather, we wish to illustrate how perspectives and disciplines are frequently integrated into the community. As argued by Bin "[t]his flexibility means that this community is a place where researchers can combine and re-combine perspectives without typical disciplinary constraint, with unusual and insightful results" [45, p. 5]. The acknowledgement of this wide breadth of attitudes and mindsets is then one of the core motivation behind this thesis, which focuses on the discovery of values and assumptions in order to support the work of music technologists engaged in the design of DMIs.

2.1.2 *Instrumentality or instrumentalities?*

Researchers and musicians engaged with new instruments have devoted considerable efforts to emphasise the peculiarities and idiosyncrasies of DMIs [244]. Instrument makers often ask fundamental questions about the identity of musical interfaces in view of their complex socio-technical origins [161, 270]. Why and when can a given technology be defined as musical instrument? How can it be recognised as such? What are the similarities and differences between acoustic, electronic and digital instruments or other sound-based information technologies?

In the past years, the notion of *instrumentality* has been considered by composers, designers and musicologists engaged working on and with DMIs. Instrumentality refers to those features that determine the specificity of a musical instrument as distinguished from other sound-producing devices, where it is generally acknowledged that musical instruments are something more than sound-producing devices.

In his 1987 article entitled *Instrumentalities*, musicologist David Burrows [78] addresses musical instruments by focusing on the relation between instruments and players. He suggests that a musical instrument is ultimately defined by the intentions and purposes of the person that interact with it.

Joel Ryan uses the term *instrumentation* to describe a compositional attitude which "extends from the mechanical design of sensors and controllers, through the electronics and software of interfaces and finally to the modelling of the higher level relations between performer and composition" [312, p. 3]. Physical effort is a key element for Ryan which rejects the idea of the computer as "labor saving device" and suggests that DMIs can be view as "physicalized models" allowing for the subtle exploration of musical ideas "at the expense of comfort" [ibid].

Also Cadoz proposes a view on instrumentality grounded in the "sensory physical phenomena" which should follow mechanical relationships conforming to consistent energetic exchanges. The emphasises is on "the ergotic character of the instrumental interaction, its multi-sensoriality and the enactive point of view linking action and perception" [79, p. 227].

Alperson instead considers "the intention to use the object as a musical instrument" pointing at the fact that musical practices are always culturally situated and instruments are not mere material objects but they are socially and historically constructed and embedded [5, p. 38]. In line with this view, Cance et al. presented an interview study in which different music technologists had to give their personal

definitions of musical instrument [87]. As a result, they argue that instrumentality is not so much dependent on the properties of a device itself, but rather on the actions and meanings that are associated to a given technology.

Torre & Andersen discuss how the act of perceiving a digital object as a musical instrument can be considered as directly proportional to the amount (and quality) of time invested in its development and refinement [348]. They support this idea with a case study based on the work of Michael Waisvisz and his 30-year long development of The Hands.

Based on an extensive review of related literature Hardjowirogo introduces a preliminary inventory for the definition of what she calls "criteria of instrumentality" [161]. This inventory is based on recurring topics associated to this debate such as sound production, intentionality, learnability and virtuosity, control and immediacy, agency and interaction, effort and corporeality, cultural context and audience perception.

Overall, musical interfaces often stimulate researchers to problematise the ontology of contemporary instruments, sometime highlighting their unique and special qualities [239, 342], and sometime appreciating the common traits they have with acoustic and electric artefacts [368].

We would argued that instrumentality is probably best viewed as a dynamic concept that is not tied to the object *per se* but is rather conditioned by the broader socio-material ecosystem as well as the subjective perception of symbolic, intellectual and physical features [155].

The references here collected are not intended to provide a comprehensive overview on the ways music technologists conceptualise their instruments. Rather, our aim is to loosely describe the diversification of *instrumental views* we can find in research contexts.

In this regard, musicians often share diverse autobiographical accounts on the integration and understanding of new technologies within their musical practices. For instance, Thor Magnusson examines his journey while learning a new musical programming environment for live coding, and how this affected his musical work [242]. Rebecca Fiebrink and Laetitia Sonami instead report on their work on the development and use of machine learning tools in compositional, educational and research contexts, considering the opportunities and challenges involved in using machine learning over many years of practices [128].

Particularly relevant for this thesis is the article by Pamela Z *A tool is a tool* [381]. She considers how the gradual adoption of digital technologies facilitated

a transition from singer and songwriter to broader sound-art and performance oriented practices, involving the use of body gestures and movements as well as found objects and sounds. In this text, the artist supports the idea that *a tool is just a tool* and therefore "[w]hat is really required to make good art is a good artist" [p. 361], a view that is in contrast with some of the pages of this thesis (see Section 2.2 and 4). However, she also acknowledges that tools often influence the work of an artist, and provides many examples on how her fascination with computers had great impact on her work.

Pamela Z suggests that technologies, as well as musical practices, are affected by cultural influences. In particualr, she reflects on the predominance of male artists and researchers in music technology as a consequence of the fact that "our culture has always socialized women to feel less confident working with mechanical or electronic devices, and people in general continue to have less confidence in women's abilities with them" [p. 358]. From this view point, the mindset promoted by Pamela Z strongly resonates with the approach promoted in in the dissertation, which aims to take into account both technological and socio-cultural factors while also acknowledging that "[t]here are as many ways of working with tools and as many attitudes toward the tools as there are artists using them" [p. 361].

Overall, the rich debate around the notion of "instrumentality", which is not the central focus of our work, provides us with a sense of these different techno-musical outlooks. Our starting point is that there are no obvious considerations. The research questions and methods explored in this dissertation aim to support the critical work of instrument makers suggesting a few strategies to make explicit and carefully meditate technological concerns and musical values before moving into the implementation stages.

2.1.3 *A practice-based attitude*

Magnusson writes that "instruments are actors: they teach, adapt, explain, direct, suggest, entice. Instruments are impregnated with knowledge expressed as music theory ... they explain the world" [243, p. 79]. Such directivity is equally true of music notation [244] and music programming languages [277]. Impett then argues that (music) technology directly suggests many of the metaphors we live by [194]. Such views imply that technology largely shapes our abilities to imagine and compose sonic interaction.

McPherson and Tahıroğlu consider these influences through the lens of *idiomaticity*: "patterns of instruments or languages which are particularly easy or natural to execute in comparison to others" [259, p. 53]. They suggest that similarly, patterns which are idiomatic to a digital tool will also disproportionately appear in the objects and systems created with that tool. On traditional instruments, musical patterns which naturally fit the movements of the body often disproportionately appear in improvisation [104, 338]. Just as an improvising pianist may reach for chords that fit easily under the hand, the idiomatic patterns of a digital instrument will suggest certain musical structures, gestures and cognitions [259].

An in-depth reflection over musical tools often leads researchers to develop models of interactions that fully acknowledge the influence that technological artefacts have on creative domains, thus considering artistic actions and outcomes as "agency shifts in the mid-ways between person[s] and thing[s]" [274, p. 130]. Within the NIME contexts, it is possible to associate these approaches with critical and creative methods such as as practice-based or material-oriented [3] – see amongst others [347, 355, 149, 167, 203].

Musicians promoting such mindsets often "view technological interactions less as means to particular ends, and more as ends in themselves: the tools are not conduits to particular material, but are the material themselves" [274, p. 131]][4]. Musical practices are then asserted for their exploratory connotations as composers and performers, "in conversation" with the materials, navigate a web of influences which include ,amongst others, digital tools and instruments as well as physical environments, scores and emerging sonic structures.

An example of such research practice is the project *One Knob To Rule Them All* in which Bowers et al. reflect on "a variety of design issues were explored including: mapping, physicality, the question of control in interface design, reductionist aesthetics and design strategies, and questions of gender and power in musical culture" [72, p. 433]. Their approach then involved the development of experimental musical instruments and related performance practices which partially functioned as reflective provocations into how NIME research is conducted in artistic settings.

Gurevich instead adopted a practice-based attitude to promote an "ecological view of music-making" which challenges the traditional model of music as communication, the rigid distinction between composer-performer-listener as well as the location of agency across human and non-human factors [154]. While pro-

3 See [114] for a discussion of the different shadings between research that is practice-based, practice-led, and so on.

4 See Section 2.2 for a more detailed discussion on the issue of *means becoming ends*.

viding a first-person account on the design of instruments for the performance of pieces from the contemporary repertoire Gurevich then explored how musical meanings emerge from the "noise" that arises through the interactions of the nodes of a network "that allows for flexible, mutually informing relationships between diverse actors" [ibid p. 165] – including composers, performers, spectators, instrument makers, digital systems, scores and stylistic conventions.

Such views resonate with Donald Schön's notion of reflection-in-action as a "reflective conversation with the situation" [319]. According to Mudd: "Schön emphasises the importance of a receptiveness on the part of the user (or the designer) to what comes back from the material in question: how they resist, surprise, and help to reframe the practitioners perspective of their activity" [274, p. 130].

In contrast with the scientific mindsets, in practice-based methods the researcher-practitioners often undertake different roles as while making artefacts and performing with them, they "examine latent research themes, explore developing ideas about practice itself or undertake experiments related to a central topic of interest" [90, 378]. The musical artefact (intended in a broad sense) is therefore a focal point of the research project as it is "both an outcome of the research, and also an integral part of the research method" [ibid].

Creative practices then become precious opportunities for a self-reflection that can make tacit knowledge communicable, provide insights into creative processes and point towards larger socio-material research themes beyond the finite work. For instance, Waters reviews a series of situated musical activities (including his own works and those from colleagues) to discuss different socio-cultural entanglements that "make instruments musical"; an ecosystemic view that aims to examine "what happens in the areas of ambiguity between musicians, their instruments and environments" [368, p.2].

Besides providing an overview of one of the foundational NIME research attitudes, this brief overview identifies the epistemological grounds from which this thesis moves [5]. As a result, the research presented in this dissertation privileges a practice-based approach in which the creative making of musical artefacts is considered simultaneously as an end in itself and a way to reflect on our practices, tools and cultural settings.

Overall, we are aware that the analyses and considerations introduced in the following chapters will inevitably reduce the complexities and richness that characterise the artefacts created by the musicians involved in our research. Our focus

5 I should declare here that, within NIME research, practice-based and contemporary music perspectives are those to which I am closest to, for their humanistic sensibilities and their artistic affiliations.

is indeed on a small selection of source of influences. However, in spite of their narrowness, the insights and lessons we learned have been gained through an art-oriented, critical and holistic attitude that recognises the networks in which practitioners and instruments are enmeshed.

2.2 THE POLITICS OF TECHNICAL ARTEFACTS

"Means are superior to the finite ends"
G. W. F. Hegel – [173, p. 747]

"Do artefacts have politics?" is the title of a well-known article by Langdon Winner [375] on the impact of technological devices and systems in our lives and communities. Madeleine Akrich [4] claims that "technical objects have political strength" for their ability of modify and stabilise social, economic and historical courses. In turn, Horn argues that the shared practices and cultures evolving around artefacts can be exploited to design new tangible interactions [184]. On a more fundamental level, Tim Ingold views materiality as an intrinsic guide for human action: the *grain* of materials influences our practices as the grain of the wood guides the woodworker's strokes [195].

In order to emphasise the "own weight" of technological artefacts Don Ihde proposes the notion of "technological intentionality" [192]. Similarly, Feenberg's argument on the impossibility of neutral tools recognises technology as both a product of society and a driver of societal change [126]. When the political is under scrutiny, some challenging and productive contributions come from a feminist standpoint (e.g. [32]), where technological artefacts are often considered as the non-neutral products of situated perspectives which do not necessarily take into account outer-edge viewpoints and alternative or marginal practices.

These are some of the accounts that, in contrast with a popular view that technology is a neutral vehicle for action and expression, shed light on the ways artefacts can engender or reinforce social relationships, values, institutions and power structures – see [25] for a broad and inclusive collection of StS studies addressing the socio-political implications of technology.

Melvin Kranzberg [6] well synthesised these technological discernments with the axiom "technology is neither good nor bad; nor is it neutral" [215, p. 545].

6 Melvin Kranzberg was an American historian pioneering the cultural study of technology. Kranzberg is particularly known for his *laws of technology* which he defines as "a series of tru-

Kranzberg expands this statement by suggesting that "technological developments, many complicated sociocultural factors, especially human elements, are involved, even in what might seem to be *purely technical* decisions" so that "nontechnical factors take precedence in technology-policy decisions" [215, p. 550].

Alongside the socio-political dynamics that foreshadow the design of a given technology, Kranzberg also emphasises the long-term socio-cultural implications of technological innovation, reminding us that "technology's interaction with the social ecology is such that technical developments frequently have environmental, social, and human consequences that go far beyond the immediate purposes of the technical devices and practices themselves, same technology can have quite different results when introduced into different contexts or under different circumstances" (ibid.)

Our approach to the study of the non-neutrality of technical objects is influenced by the work of philosopher Umberto Galimberti [7] who examines how the ubiquity of technology in contemporary societies radically shapes our identities and purposes [136].

Although Galimberti engages with a broad set of topics, including ethical and political issues, we pick a small portion of his discourse on the autonomy of tools, which is in turn based on the philosophies of Marx and Hegel. We roughly summarise Galimberti's argument on the ineluctability of technology in two key points: *means become ends*, on the modalities through which means can prevail over needs and purposes [252], and *quantity affects quality*, on how the quantitative increase of a given phenomenon imposes a qualitative change to its context [174, 173].

2.2.1 *Means become ends*

The process through which means become ends has been described by Marx [Capital, book I, chapter V - 252] in his critique of modern economies [136]. A classic example is the evolution of the role of money: money can be considered a means for the acquisition of goods whose production and consumption are the aim of the economic process. Nonetheless, in modern society, the possession of money has

isms deriving from a longtime immersion in the study of the development of technology and its interactions with socio-cultural changes" [215, p. 544].

7 Galimberti's work, which has been translated in many languages but not yet in english, largely draws on the philosophy of his master Emanuale Severino which identifies the origins of the techno-scientific culture that predominates our time in the philosophy of Aristotle and Plato [324].

gradually become the main condition for the achievement and satisfaction of most goals and needs. Thus, money becomes the *absolute end* to which everything else is subordinated – including the production and consumption of goods, which in turn become means for the accumulation of money.

The tendency of means to become ends is well described by Severino [323] which illustrates this inversion in various social, religious, economic and technological contexts. In philosophical settings this phenomenon is often identified as *heterogony of ends*, whose origin can be traced back to the works of Giambattista Vico and Wilhelm Wundt.

Technology is commonly conceived as a means to facilitate human action for specific purposes. However, we are approaching the situation where most our needs and objectives can be achieved only through technology [136]. In global-north societies, technology not only mediates almost every aspect of our life, but it sets the very condition for the realisation of most human activities. Technology then ceases to be a simple tool and it becomes an end, the achievement of which any other purpose is subject to. Galimberti notes that also Hegel, before Marx, considers the relation between means and ends: "the plough is more honourable than are immediately the enjoyments procured by it and which are ends. The tool lasts, while the immediate enjoyments pass away and are forgotten" [173, p. 747].

What about the technologies of music? We argue that musical instruments are often understood as both means and ends, simultaneously perceived as points of departure and arrival. The significance of traditional instruments goes well beyond their mere functional elements, to the point that instruments become emblematic of a given culture, also embodying social, historical and religious connotations [34].

In western cultures, the instrument is clearly a crucial element for most musical practice and it is often recognised as coalescence of embodied, cognitive and emotional features [282]. The focus on the instrument as a goal in itself is indeed the main concern of most primary training programmes, where pupils are encouraged to learn the instrument. However, musical instruments suddenly become means of expression once musicians start to develop a personal style, pursue a given aesthetic canon or study a certain repertoire, thus conveying music with the instrument.

As suggested by Théberge, instruments can be understood in terms of "their place in a network of relationships - an assemblage - with other objects, practices,

institutions and social discourses" [345, p. 59]. Accordingly, different networks might contribute to position an instrument within the continuum between means and ends. We would indeed argue that, given a particular musical context, these two conceptions often coexist, to the point that it is often difficult to identify which of the two prevails. With only a few exceptions (e.g. the human voice), musical tools are an essential condition for the (re)production of music: there is no music without a technology of music – the term *technology of music* here intended in a broad sense, also including systematic and analytical representations, such as musical scores [241] and music theories [373].

Let us apply this argument to two specific attitudes found in academic digital music research (though by no means limited to academia). The idea of music technology as a medium for expression and communication seems to be particularly grounded in techno-scientific research communities – see amongst many others [88]. However, researchers in engineering and computer science generally target technological development as the primary research objective.

We can then clearly observe the transformation of means into ends as music practices become instrumental to technological research and development. Such work typically relies on quantitative methods (i.e. measure, model and evaluate) with the risk of reducing musical instruments, performance and expression to issues that should be essentially solved or optimised [153, 156].

As mentioned in previous section, in NIME contexts, we also see an approach to musical interaction that explicitly puts musical instruments and their making at the core of contemporary musical practice, "[an] approach where the instrument becomes a material source for sonic investigations, rendering it more as an end in itself than a medium for expressing neutral musical ideas" [244, p. 124]. According to this attitude, which integrates technological research with arts practices, digital instrument design is considered as a process where musical ideas, tools and materials co-evolve in a perpetual and explorative dialogue – an exchange in which "the material kicks back" [274, p. 127].

New instruments then become a crucial source of inspiration for the emergence of creative and critical practices. Instrumental agencies [96], co-creation [127] and material exploration are some of the ideas used to qualify material-oriented practices. By drawing attention to the influence of technology, practitioners engaged with digital instruments consider music technology as "a necessary and creative

mediation that can be a source of ideas itself rather than simply a means for their transmission" [274, p. 123].

We are not suggesting that contemporary instruments are designed with a Marxist outlook. We are also aware that the two approaches here illustrated do not comprise the diversity of perspectives we can find across music technology domains. Our intention is instead to show how some of the prevailing mindsets found in sound and music computing and NIME contexts are associated with cultural dynamics which extend well beyond the scope of music technology. These attitudes seem to be in line with the general ever-shifting tendency of means to become ends - whether tacitly exploiting music as a *pretext* to optimise the latest technology, or explicitly considering the critical exploration of music tools and materials as a core element to the development and use of new musical instruments.

2.2.2 *Quantity affects quality*

If technology is an end in itself, it follows that its exploration, improvement and expansion will be ubiquitous. According to Galimberti, the idea that an increment in quantitative terms of a phenomenon imposes a qualitative change has been first outlined by Hegel [174, p. 263]:

> "[I]f the quantity present in measure exceeds a certain limit, the quality corresponding to it is also put in abeyance. This however is not a negation of quality altogether, but only of this definite quality, the place of which is at once occupied by another".

Hegel provides material examples (ibid.):

> "[T]he qualitatively different states of aggregation water exhibits under increase or diminution of temperature. The same phenomenon is presented by the different degrees in the oxidation of metals. Even the difference of musical notes may be regarded as an example of what takes place in the process of measure the revulsion from what is at first merely quantitative into qualitative alteration".

Galimberti extends this argument to the contemporary condition where technological presence has drastically increased. On a macro scale, technology is, more than ever, pervasive and affecting our everyday life. On a micro scale, a single artefact integrates an enormous amount of scientific knowledge and expertise. As

a result of these quantitative variations, our relationship with technical objects qualitatively changes.

As long as the available means were barely sufficient to satisfy specific needs, technical artefacts could still be considered as simple tools subordinated to the fulfilment of human needs and goals. Instead, when technological ubiquity drastically rises, means themselves, and not us, increasingly determine the range of possible ends. In these terms, as *creators of ends* [8], contemporary tools radically influence our actions as we can only choose within the possibilities that the technological means make available.

Once again, let us translate these reflections to the context of musical devices. Due to its breadth and complexity, the evolution of musical instruments is a challenging issue which exceeds the scope of this dissertation. Nevertheless, it seems reasonable to trace a path that, through sometimes convoluted lineages, leads to the progressive appearance of first acoustic instruments, then electronic instruments and finally digital musical interfaces. According to this view, Magnusson [239] identified a few salient features that qualify the making of these instruments: in a nutshell, luthiers of acoustic instruments have traditionally acquired their skills mainly through embodied and iterative practices. Such non-theoretical knowledge is achieved through apprenticeship and builds on a deep awareness of materials, playing techniques as well as shared aesthetics and cultural practices.

In contrast, (analogue) electronic instrument designers are instead faced with an increased logic of calculation, science and engineering. They usually have an understanding of electromagnetism and wave propagation as well as components such as capacitors, inductors, and transistors. Unlike Antonio Stradivari, Robert Moog could draw from Fourier's and Helmholtz's theories while designing modular oscillators and filters.

While drawing this distinction we also acknowledge that many contemporary luthiers of acoustic instruments rely on science and engineering, and we do not endorse a romantic notion of lutherie as being stuck in the 18^{th} century. For instance, a remarkable mix of novel hardware/software tech and classical instrument making can be found in the work of the luthier Hans Johannsson, which develops electric violins with embedded convolution engines based on impulse response

8 This term is borrowed from Galimberti [136] and it is here used to evoke poetically the fact that our actions are less and less inspired by human intentions and needs, and increasingly driven by the opportunities offered by technical means – we do not because we want but because we can.

measurements of high quality stringed instruments [9]. Moreover, collaborations between traditional luthiers and audio engineers often lead to the production of new research knowledge (e.g. [197]) as well music technology products [10].

However, useful insights on this matter can be found in the work of Armitage et al. which interviewed violin makers in order to inform NIME practices [24]. This research highlights how violin makers tend to "rely implicitly on their tacit, embodied abilities and experiences" [p. 397] which requires years of practices "where repetition and flow are important factors for internalising the making process" [p. 395]. Even if the luthiers involved in the study often considered scientific knowledge and engineering tools (e.g. acoustic theory and visualisation tools) useful aids, these means were often viewed as limited in terms of practical applications. As mentioned by one of the interviewees: "[w]e rely on our hands" [p. 396].

Electronic instruments may come with instructions and schematic diagrams that describe their behaviour, whereas "acoustic instruments do not come with a manual, they are manual" [244, p. 107]. Makers of digital instruments are instead often busy with coding "a set of instructions turned into binary information converted to an analogue electronic current in the computer's soundcard" [239, p. 172]. The digital instrument assemblage possibly requires a computer, a display, a sound card, an amplifier, speakers and some sort of performance interface. Each of these units relies on thousands of materials and specialised components, which in turn were eventually assembled thanks to a multitude of industrial processes. In Magnusson's words: "from the perspective of Latour's actor-network theory, the networks enrolled in the production of digital instruments are practically infinite. There is an impenetrable increase in complexity, which means that the inventor shave to constantly rely on black boxes" (ibid.).

Beside emphasising the "impenetrable complexity" linked to the production of digital technologies, the "black box" analogy seems particularly appropriate as it points at the limitations of human intellect to fully grasp the totality of processes operating inside a given digital instrument. Such considerations might resonate for those researchers active in the domains of machine learning for audio and music applications, where we are unable to properly understand the functioning of our algorithms, and users are left only with the possibility of selecting one of the many outputs generated by the system. Still, to a certain extent, this condition

9 See the OTHAR project in Hans Johannsson's website – last access April 14, 2023

10 See Vsound 2, a stand alone pedal with bundled impulse responses of acoustic violins – last access April 14, 2023

is not unique to digital technology: it also arises when playing an acoustic piano, though arguably on a smaller scale.

We do not endorse the view of a "fundamental difference of the acoustic versus the digital" [239, p. 175]. Instead we suggest that the modalities through which we encounter an instrument vary, in qualitative terms, over a continuum, ranging from the musical practices in which the body is the only instrument required (e.g. singing) to the latest deep learning musical interface (until the next "better" technology will made artificial intelligence obsolete). Musicians can then feel the smallest qualitative variation between rather similar instruments – indeed, despite decades of advancement in digital piano technology, acoustic and digital pianos are often perceived somehow as qualitatively different.

In an effort to avoid an overly radical technological determinism, we treat cultural forces and technical processes "as two aspects of the same phenomenon" [60, p. 77]. Digital keyboards are a good example of how a technological assemblage, based on a general purpose processor, can *remediate* (i.e. refashion or translate – see next section) specific notions of music and music performance [60] – i.e. those already inscribed into an acoustic piano. Théberge indeed argues that a crucial factor for the maturation of the synthesiser industry was "the decision by a number of engineers and inventors ... to move away from making unique devices to meet the specialised needs of avant-garde composers working primarily in institutionally based electronic studios and towards the manufacture of affordable, keyboard-oriented musical instruments" [344, p. 55].

Théberge also describes how the advent of microprocessor in the mid-1970s profoundly impacted the keyboard industry: "whereas the Minimoog (1970) contained about three hundred transistors and took Moog about six months to design, an instrument such as Korg's Wavestation (1990) contained the digital equivalent of close 300 million transistors and occupied some twenty people for a period of over three years" [344, p. 70]. Considering the number of socio-technical processes behind (and inside) a given digital instrument allows us to appreciate how digital artefacts necessarily imply an increased layering of inscriptions [4] which, far from being solely technical, are also culturally situated. We might then say that *each component* of a musical digital interface is then an active mediator of technical functions, socio-cultural norms and musical values.

2.2.3 *Inscriptions and (re)mediations*

For some time sociologists of technology have argued that while drafting objects and materials, designers necessarily make hypotheses on the *world* into which a device will be used [84]. In her article *The De-Scription of Technical Objects* Madeleine Akrich proposes the notion of the *script* to illustrate how artefacts *de-scribe* potential scenarios of uses which were previously *in-scribed* into technical objects. The scenario associated to an artefact might then reflects a body of tacit knowledge and norms assumed for the future *contexts* of a given technology:

> "Many of the of the choices made by designers can be seen as decision about what should be delegated to a machine and what should be left to the initiative of human actors. In this way the designers express the scenario of the device in question: the script out of which the future history of the object will develop" [4, p. 216].

Akrich introduced the notion of *script* in order to frame the processes through which "designers define actors with specific tastes, competences, motives, aspirations" [4, p. 208]. Akrich argues that "designers also assume that morality, technology, science and economy will evolve in particular ways", thus a large part of the work of makers is that of *inscribing* a vision into an object. While interacting with a technology we then interpret the script envisaged by the designer, a set of predictions which include users' aspirations and behaviours.

In this way a technologist provides a "libretto" delineating the subsequent events and uses related to the object. Although users will add their own interpretation, it is likely that the script will become a major factor for understanding the interaction between the object and its users. Based on this, it is possible to argue that, while building an instrument, a luthier transfers into the object specific cultural knowledge and musical meanings. A violin maker envisions for her instrument cultural contexts (e.g. music schools or concert spaces), musical aesthetics (e.g. classical or folk music), physical behaviours (e.g. musical techniques and ethical conducts) and so on.

Beside the technical expertise, making of an instrument entails the materialisation of pre-existing musical values and norms. Following with the case of the piano, the keyboard interface *de-scribes* specific musical knowledge to impose twelve-tone equal temperament, percussive (impulse/decay) note events as well as certain assumptions around diatonic scales (black/white keys), the spatial proximity of

neighbouring frequencies, the reach of the hand to just over an octave, etc. Considering the complex evolution of musical instruments and their practices within the Western history, NIME designers inherit a centuries-old body of knowledge. New instruments are indeed often discussed in relation to traditional instruments [312, 205, 163] suggesting that pre-existing socio-materials routines are easily exploited to inform the design of new instruments as well as to discuss and evaluate them.

Acoustic instruments have traditionally evolved through relatively slow processes, and, far from being obsolete technologies, they steadily persist in contributing to most of the musical contexts. On the other hand, in fast-paced electronics and computer industries, technological obsolescence is both the rule and the rationale for increased consumption. Devices which once stood out for their novelty and performance gradually fall into disuse, supplanted by newer and ostensibly better technologies [98, 298, 50]. As a consequence, while it is still possible to get sounds from a bone flute crafted more than 30,000 years ago, due to the accelerating cycles of innovation and obsolescence, a music software that is more than a decade old might just as well be prehistoric.

Nevertheless, the cultural evolution of music values and aesthetics does not necessarily proceed at the same speed of technological advancements. The chasing of perpetual innovation often lead us to focus on the technical element and forget about (or take for granted) socio-cultural norms and values. By constantly chasing what is ostensibly new we end up forgetting (or ignoring) the history of our subject, which, amongst other things, implies a loss of awareness of our tools and techniques.

The most obvious consequence of such is that "new" instruments frequently repurpose the same old good musical values which tacitly keep influencing the production of "new" music. On this matter, Emily Dolan has written compellingly about the way that our conception of music itself is tightly bound up in the keyboard as an interface [115].

On that basis, a useful conceptual tool for the critical study of technology is the notion of *remediation* [60]. Following McLuhan's intuition that "the content of any medium is always another medium" [256, p. 23] , Bolter and Grusin discuss remediation as "the formal logic by which new media refashion prior media forms" [60, p. 273]. This implies that characteristics typical of an existing media are transferred into the new media. Digital media often remediate analog media, for

instance the pages of a web portal might remediate those of a printed newspaper. More specifically, Bolter and Grusin suggest that:

> "[A]t this extended historical moment, all current media function as remediators and that remediation offers us a means of interpreting the work of earlier media as well. Our culture conceives of each medium or constellation of media as it responds to, redeploys, competes with, and reforms other media. In the first instance, we may think of something like a historical progression, of newer media remediating older ones and in particular of digital media remediating their predecessors. But ours is a genealogy of affiliations, not a linear history, and in this genealogy, older media can also remediate newer ones" [60, p. 55].

In this context, the notion of medium should be understood in a broad sense. To clarify this, we rely on the discussion provided by McLuhan in the opening pages of *Understanding Media* in which he argues that although a light bulb does not have contents in the way that a newspaper has articles, it is a medium that has a cultural and social effect – "a medium without contents" that produce space through its "mere presence" [256, p. 8].

According to this perspective, the design of a digital instrument involves, to a certain extent, a migration process through which features associated with existing musical technologies and contexts are re-configured through a novel interface. Thor Magnusson argues that "what new instruments translate from earlier technologies are not simply the simulation of an interface, but a whole constellation of embodied contexts" [243]. This rationale complements Bolter and Grusin's view, according to which "what is new about new media comes from the particular ways in which they refashion older media" [60, p. 15].

A clear example of this phenomenon are modular synthesisers which directly refashion features coming from prior information technology. Beside material features, remediation is also understood as the technological inscription of abstract knowledge and representations – see the idea of the *script* previously introduced. In the case of modular synths, knobs, switches, rack modules, cables, etc. are not just physical elements shared between different interfaces. Being previously used as part of measurement devices, these materials convey techno-scientific notions such as fine tuning, accuracy, predictability, numerical representation, modularity and automation.

Other examples of cultural remediation within the context of music technology are musical tuning and tempo. The equal temperament tuning system, which

provided the basis for the development of the MIDI communication protocol, is probably one of the most remediated notions in current music technology – see, amongst others, the piano roll displayed in most Digital Audio Workstation (DAW) software. Sequencers and drum machines instead are generally concerned with the remediation of a very specific type of musical tempo: a never changing four-based subdivision.

2.2.4 *On socio-technical constraints*

The complementary notions of inscription and remediation offer a circular view of music technology: pre-existing aesthetics are embedded into new instruments, which actively repurpose them and therefore influence the production of new music and so on – see Chapter 4 and Chapter 7 for a more extended discussion on the recursive processes that characterise DMI design and performance.

A confirmation of the presence of these iterative patterns is the widespread of Western music theories in popular music production softwares. In recent years, musicians and researchers started to grow awareness on this matter [11] In his book "Uproot" Jace Clayton writes:

> "Digital tools [..] shrink us down to a small set of options. Virtually all music software is made in the United States or Europe. These programs all tend to do the same thing, in varying amounts, and that thing defaults to a narrow concept of what music can or should be. It matters because more and more music is being made using this tiny number of systems. Software tools are never neutral. They reinforce their builders' blind spots and biases and, once widely distributed, play an active role in maintaining those assumptions." [94, p. 137]

Moving from this perspective, Clayton describes the development of the *Sufi Plug Ins*: a set of software modulus conceived while collaborating with musicians coming from the North African (Berber) traditions. In this context, Clayton vividly illustrate the incompatibility between the square patterns encoded into his music software and the poly-rhythmic diversity that characterises Berber music. Another

11 For instance, the theme of the 2022 NIME Conference is "Decolonising Musical Interfaces" which aims to challenge the socio-cultural implications and aesthetic limitations linked to Western-centric approaches.

issue encountered was the difficulty to accommodate with his synth the quarter-tone notes played by his fellow musicians.

Clayton then approached the development of the *Sufi Plug Ins* by consciously privileging musical values and knowledge proper of the Maghrebi tradition: "I didn't want more choices [..] I wanted fewer, better choices [..] [w]ith my presets and assumptions embedded. [..] I could do that by incorporating different defaults, different assumptions, different blind spots" [Ibid. p. 144-151]. This attitude, which resonates with the mindset adopted in this thesis, acknowledges the inherent limitations linked to a musical tool, and, rather than designing more powerful technology, aims to critically embrace the normative musical values inscribed in digital production tools.

The idea that instruments support and facilitate specific cultural notions and practices is well established beyond the music technology domains [104]. In particular, the notion of *affordances* [284] and that of *constraints* [57], often found in NIME and HCI contexts, present strong affinities with the arguments developed in this section.

A given object can be examined based on the specific actions it *affords* – i.e. makes possible. Inspired by the work of Gibson [143], Norman introduced the concept of *perceived affordances* in HCI:" the properties that the agent perceives as possible actions upon an object" [283, p. 63] – a perception that is in part socially constructed and therefore might chance across places and communities.

As in HCI literature the term "affordance" is highly varied in interpretations and definitions, it might be beneficial to consider the complementary notion of *constraints*, which gained through the years a certain popularity in NIME contexts [292]. Indeed, Magnusson suggests that "affordances and constraints in musical instruments are two sides of the same coin, but with a change of focus where affordances point to features that make things possible and constraints define the limits of the possible" [240, p. 71].

This view is particularly relevant for the research presented in Chapter 4 which aims to unpack some of the socio-technical factors that contribute to the development of simple digital instruments, examining how the values and knowledge inscribed into digital music tools (e.g. Pd audio programming language) simultaneously *push* towards particular directions and inhibit other possible paths.

In the context of NIME design, Magnusson describes a model of constraints that resonates with the framework of this dissertation. Three types of constraints are

identified: "objective constraints (including the affordances of the physical gestural interface and the limitations of the programming language, protocols, or hardware), cultural constraints (the style of music for which the system is designed), and subjective constraints (the background and experience of the designer)" [240, p. 65].

The notion of constraints is particularly suited to describe specific practices linked to the design of a DMI – see for instance mapping strategies as well as procedural audio and algorithmic composition methods, which often remediate long-lasting attitudes inherited from post-Cagean and computer music traditions. However, the constraints' lens might result reductive to examine broad socio-cultural dynamics, as well as subjective attitudes towards music and technology. In this dissertation, we then adopt the concepts of inscription and remediation described previously. Nevertheless, the work reported in the following chapters echos the approach drawn by Magnusson, as cultural, technological and subjective influences on DMI design are respectively explored in Chapter 3, 4 and 5.

In Chapter 7 we further discuss the notion of constraints as fundamental sources of creativity in the context of DMI. Based on the findings presented in the empirical chapters, we will defend the idea that the constraints (whether inscriptions or (re)mediations) that characterise digital instruments have the effect to emphasise the *idiomaticity* of the musical interactions supported by these interfaces [341, 265, 355].

Finally, besides relying on different theoretical systems compare to those usually found in NIME and HCI literature, the ideas introduced in these chapters aim to provide a perspective on the presence of constraints and affordances beyond the properties of a given DMI. On one hand we offer a holistic view on the relationships between contemporary western cultures and technology, see the argument *means becomes ends*. On the other, the concept of *quantity affects quality* lets us appreciate how the myriads of technological layers present in digital instruments constrain and influence the musical interactions they promote.

According to this view, the work presented in this thesis critically examines particular digital music tools in order to provide an account on the ways a given music technology facilitates (or constrains) the development of interactions and aesthetics. Through this socio-material focus, which mainly relates to the work presented in Chapter 4 and 6, we then explore an approach to reveal the values and patterns inscribed in and remediated by digital instruments.

"I cannot obtain any truth whatsoever about myself, except through the mediation of another. The other is indispensable to my existence, and equally so to any knowledge I can have of myself. Under these conditions, the intimate discovery of myself is at the same time the revelation of the other.."

Jean-Paul Sartre – [315]

It is common knowledge that computer interfaces vary across cultures: designers present information in different languages, use different iconography to designate concepts, and employ different representations and semantics. Since the early 1970s, the ergonomics community has been interested in the development of practical guidelines aiming to tackle the issues of usability and cultural differences (for an overview see [83]). In general, rather than offering ready-made solutions, design principles point out the need of increasing cultural awareness and critical thinking.

While discussing the processes through which new technologies refashion existing paradigms, Bolter and Grusin note that each media "participates in a network of technical, social, and economic contexts; this network constitutes the medium as a technology" [60, p. 65]. Such thinking poses questions on how different "socio-economic networks" might differently interpret the same interface and which traits of a culture most notably shape the comprehension of a given digital interface.

The very notion of "culture" is a complex and problematic one. In the following sections we will attempt to provide some workable "definitions" which draws on previous interface design research. The HCI literature provides a great variety of interpretations of culture, generally relying on anthropological and sociological studies – e.g. [335, 177]. However, in HCI domains the tendency is to operationalise the concept of culture in regards to the specific needs and difficulties encountered by designers while developing whether cross-cultural or culture-specific technologies.

Clearly, culture is not a homogeneous construct and the absolute boundaries of a specific socio-cultural context cannot be determined. Cultures are generally conceived as dynamic entities where different communities constantly interact with and influence each other [106]. Thus, culture is permanently susceptible to change and impossible to frame in rigorous and scientific terms. For these reasons, many HCI principles and guidelines studies leave to the readers the task of identifying

relevant elements in function of the social differences, economic effects and cultural factors that characterise a given context [330].

Based on these premises, our attitude towards technology research resonates with the third HCI paradigm described by Harrison et al. [164] [12]. As posed by Frauenberger, this approach "focused on interaction that is situated in the social and bodily complexities of a messy, real world" where "[t]he cultural and emotional aspects of interaction became more central to the experience of people with technology" [130, p. 2].

Often drawing on feminist philosophy of science (e.g. [32]), the researchers adopting this paradigm tend to consider the production of knowledge as circumstantial and contingent. One of the foundations of third wave HCI research relates to the notion of *situated knowledge* introduced by Haraway [160]. Stated briefly, situated knowledge questions the traditional idea of objectivity HCI inherits from engineering – i.e. the researcher as neutral collector of empirical knowledge and the object of inquiry as a passive and stable.

A close argument to this theory often adopted in HCI contexts, is Lucy Suchman's distinction between *plans* and *situated actions* [336]. Suchman challenges the design of interactive systems noticing that, beyond abstract intentions, human action is constantly constructed and reconstructed from dynamic interactions with the material and social worlds [337]. Overall, these perspectives stress the fact that knowledge is always bounded by socio-material factors, and a good part of the researcher's job is to make these limitations visible as much as possible.

In line with these epistemological values, HCI practitioners proposed a variety of situated approaches for the engagement with communities and cultures. These include Situated Design [330] and community-based Participatory Design [329]. These attitudes focus "on the social constructs and relations of groups in settings" [112, p. 183] and examine design practices as always carried out with partiality and from a specific and embedded position.

12 The evolution of interaction design research is often outlined in relation to the HCI "waves" (i.e. paradigms), each supporting increasing levels of intellectual diversity [59]. The first mainly relates to an engineering understanding of human-machine interaction focusing on task optimisation, and the second instead acknowledges the need of studying social contexts and human behaviours for technology design [58]. A fourth wave, embracing post-human perspectives and relational ontologies, has been recently suggested by Frauenberger [130].

Particularly relevant for our research is the work of Michael Horn which, drawing on Saxe's *form-function shift* framework [317], proposes an approach to tangible interaction design concerned with the "overall experience around an interactive artefact by cueing productive patterns of social activity" by evoking existing cognitive, physical and emotional resources [184, p. 117]. According to Horn, while designing a new object, it is therefore possible to elicit, augment or deviate the interactions associated with existing objects, their environments and cultures of use.

The role of cultural form in interaction design (i.e. the norms and behaviours we socially inherit) has been thoroughly explored in HCI domains. The concepts of *perceived affordances* and *social signifiers* introduced by Norman are examples of the theoretical basis grounding situated design research [13]. Another influential approach in line with these perspectives, relates to the research of Dourish on embodied interaction, which envisions the relation between interaction, objects, and meaning as constructed through social and cultural practice [116].

Our work relates to these research trends sharing their overall sensitivities and concerns. In particular, our intention is to discover the cultural forms and pre-existing representations that tacitly influence the design of a digital instrument.

2.3.1 *A psycho-sociological outlook*

In order to set the our research in context, we introduce a few conceptual tools coming from social psychology studies. These will help to shed some light on the modalities through which individuals and groups co-develop shared representations and imaginaries.

Aristotle is one of the first to observe that the individual is unknowable in herself as her intelligibility is inherently linked to the social dimension – *zôon politikón*: social animal. According to this perspective, identity can be viewed as social gift and reality might be essentially understood as socially constructed [41]. From a psycho-sociological viewpoint, this dissertation relates to two well known frameworks: *schema knowledge structures* (or mental models) [33, 294] and *social representations* [273, 119].

While suggesting schema as an approach to the interpretation of technology within HCI research, Callahan provide a concise description of this notion: "[schemata]

13 In a nutshell, a design provides *clues* [283, 284] and designers can exploit them to elicit meanings and behaviours which are socially shared and interpretable [285].

include mentally run scenarios to anticipate effects of actions. We call upon schemata to make sense of, or to help us interpret, information that comes to our senses and to enable us to be cognitively efficient in responding to our physical and social worlds" [83, p. 268].

Based on the schema framework, Callahan also suggests a relatively concise notion of culture which we adopt for our research:

> "[C]ulture can be understood as a complex construct encapsulating shared values, group behavioural patterns, mental models, and communication styles" [83].

The models examined by schema theories occurs when a person tries to understand and interact with the environment: experiences can be added to existing schemata (accretion), minor changes can be made to account for a more refined view (tuning), or major structural changes based on new information can occur (restructuring). When existing schemata do not explain observed phenomena, additional new schemata need to be created (schema induction) [316].

Although schema structures are often used to explain individual's experiences and behaviours, many schema theorists agree in recognising the influence of contexts and cultures on individuals' development and world interpretation [14]. As Anderson notes:

> "The knowledge a person already possesses is the principal determiner of what a person can come to know. Knowledge, in turn, is conditioned by culture. Therefore, a person's culture is a principal determiner of what he or she can come to know." [19, p. 8]

This dissertation takes advantage of the perspectives introduced by authors such as Mead [263], Schutz [320] and Goffman [144] which shows the centrality of the social dimension for the development of identities, the generation of meanings as well as the understanding of experience. Due to its focus on social interaction and communication this approach has been defined by Herbert Blumer as *symbolic interactionism*:

> "*Symbolic interactionism* rests in the last analysis on three simple premises. The first premise is that human beings act towards things on the basis

14 Schema theories are particularly popular in the Anglo-Saxon culture, and they relates to a set of psycho-sociological approaches which, inevitably, can be here only named. These include the pioneering contributions of Bartlett [33], Piaget [294] and Vygotsky [359].

> of the meanings that the things have for them ... The second premise is that the meaning of such things is derived from, or arises out of, the social interaction that one has with one's fellows. The third premise is that these meanings are handled in, and modified through, an interpretative process used by the person in dealing with the things [s]he encounters" [51, p. 2]

Within this framework, social representations theories provide an account on the ways system of values, ideas, metaphors, beliefs allow communication and practices amongst members of a given social context [273]. On a psycho-sociological level, social representations then are the processes through which groups and communities produce shared knowledge which "enable individuals to orient themselves in their material and social world" [272, p. ix–xiv].

The construct of social representations is particularly relevant for our research as it is closely related to the theme of values. Indeed, values are here framed as what is important and orient our actions towards a specific object. We therefore examine values in light of its implications and relationships with social representations, ignoring the moral and ethical connotations that are often associated to the term [15]. According to this view, values, as emerging from a culture, contribute to the generation of particular social representations.

The work presented in this research (see, in particular, the studies introduced in Chapter 3) explores musical instruments as "cultural objects" observing that their representation, being connected to different systems of value, might widely vary across the members of different musical communities.

In these terms, we will appreciate that the idea of the musical instrument does not exist as an autonomous and universal construct, but it is intrinsically situated within communities which, based on their cultures of reference, produce different representations of the object. As we will see, these collective representations then become elements of reality, secure categories [119] and influence design and musical practices.

15 Due to its moralistic assonances, I am not particularly fond of the term *value*, however, beside alining my work with existing scholarship in both the HCI and STS traditions, the choice seems appropriate in view of the function that values have in contributing to the construction of shared representations.

2.3.2 *Communities of practice*

In order to explore the influence of shared values and representations the studies presented in this thesis we will often compare the work of musicians active in different musical contexts. It might then beneficial to delineate what, in the context of our research, constitute a social group.

The situated and interactional understanding of human conduct outlined in previous sections led us to consider the work of Etienne Wenger on *Communities of Practices* (CoP) [218, 370]; a concept that has been also adopted in various NIME research to examine groups of musicians concerned with particular musical practices [250, 249, 248].

Lave and Wenger first introduced the CoP theoretical framework in 1991 [218]. Wenger developed it through the years, proposing slightly divergent definitions with the consequence of generating some confusion in the usage of the term [16]. In the context of this thesis, we take as a main reference Wenger's 1998 work *Communities of Practice: Learning, Meaning and Identity* [369], which focuses on the "social relations and meanings that grow up around a work process when it is appropriated by participants" [100, p. 537]. Wenger describes CoP as a construct which relates to three interconnected dimensions [233]:

- **Mutual engagement**: the interrelations between individuals that contribute to the creation of shared meanings;
- **Joint enterprise**: the procedures through which members work together on a common target;
- **Shared repertoire**: the shared resources and jargons used to negotiate meanings and facilitate learning within the group.

Based on these elements, Wenger provides a set of indicators to better define the main features of a CoP – see Table 2.1. An important concept linked to the CoP framework exploited in this dissertation is the notion of *legitimate peripheral participation* [218] – see in particular Chapter 6. With this concept Lave and Wenger point at the processes through which newcomers approach a community from "a region that is neither fully inside nor fully outside" [369, p. 117] and moves towards the centre through growing involvement.

16 See Cox [100] and Li et al. [233] for more detailed reviews on different usages and definitions of CoP.

Wenger highlights the importance of the *trajectories* across different levels of participation within a group as members' are increasingly given opportunities to learn and develop new skills. This progressive participation then implies that individuals gradually receive from the community (e.g. knowledge and responsibilities) but also contribute to the group by, for instance, mentoring other newcomers [369].

1	Sustained mutual relationships – harmonious or conflictual
2	Shared ways of engaging in doing things together
3	The rapid flow of information and propagation of innovation
4	Absence of introductory preambles, as if conversations and interactions were merely the continuation of an ongoing process
5	Very quick setup of a problem to be discussed
6	Substantial overlap in participants' descriptions of who belongs
7	Knowing what others know, what they can do, and how they can contribute to an enterprise
8	Mutually defining identities
9	The ability to assess the appropriateness of actions and products
10	Specific tools, representations, and other artefacts
11	Local lore, shared stories, inside jokes, knowing laughter
12	Jargon and shortcuts to communication as well as the ease of producing new ones
13	Certain styles recognised as displaying membership
14	A shared discourse reflecting a certain perspective on the world

Table 2.1: Wenger's indicators of community of practice. Extracted from [369, p. 125–6].

The notion of CoP has been also adopted by various researchers in NIME contexts to examine the emergence of shared musical practices and explore new pedagogical approaches. Particularly significant for this thesis are the reflections posed by Marquez-Borbon and Stapleton on the "value and meaning of community in interactive music research" [250].

Marquez-Borbon and Stapleton examine how the notion of community proposed by Lave and Wenger could be applied in music technology contexts, suggesting that NIME might be best described as a "community-of-communities". This configuration relates to Fischer's concept of *community of interest* where members sharing the same objectives contribute to the group from multiple domains. We may say that, in the case of NIME, participants aim to "develop a body of work related to new digital instruments from different disciplines and perspectives" [250, p. 308].

In line with this attitude, Marquez-Borbon and Martinez Avila discussed the problem of DMI adoption and longevity arguing that these issues should be tackled also considering the socio-cultural dynamics surrounding musical interfaces [249].

By focusing on the situated learning occurring within particular socio-cultural environments [75, 44], Marquez-Borbon and Martinez Avila suggest a holistic performance pedagogy taking into account broader "ecosystemic factors" which are beyond particularities of the device itself. Marquez-Borbon further investigates this approach providing a more detailed account on how through shared learning experience – including mutual playing, rehearsing, improvising, and composing – group members "came to a unified language and conceptualisation of the instrument" [248, 585].

Drawing on this body of work, our intention is to discover some of the representations we might find within different sub-communities which reflect different musical practices and histories of learning [248]. This is based on the idea that practitioners belonging to different social structures might negotiate rather divergent understandings of music performance and tools.

In short: the core assumption behind our work is that through practice and social interaction musicians develop shared *imaginaries* [17], which might reflect shared sensitivities towards specific aesthetics (e.g. musical styles and genres), modes of expressions and technological views.

The musicians involved in the studies presented in this dissertation relate to different musical backgrounds, genres, instrumental expertise and ensemble practices. These elements emerge from and are situated in different social contexts, including educational institutions and musical venues – e.g. concert halls, music clubs, festivals and traditional local events. In order to move beyond abstract framings, the following chapters provide specific information on the musical activities and backgrounds of the musicians involved in our research – see Section 3.2.2 and Section 4.2.3.

Despite being suitable for our research, the notion of *community of practice* is controversial in many aspects [100]. Researchers active in sociological settings argued that the term "community" might be rather difficult to clearly define [6, 95].

Williams noted that it has "strongly and unqualified positive overtones", given that a community of practice might not be necessarily friendly or harmonious [100]. Wenger's language and rationale mainly relate to the work place, often focusing on enterprises and organisations – see indicators 5, 6, 9 in Table 2.1. In the latest of Wenger's works on CoP [371], such connotation is emphasised, leading to a discourse that is closer to a manual for community management rather than a sociological analysis. In this regard, the functional and problem-solving dynam-

ics considered by Wenger do not automatically relate to the open-endedness and *purposeless* qualities that often characterise artistic practice.

Overall, I am aware that the term *community* is a difficult qualifier. The appreciation of shared identities within social groups should always be balanced by the acknowledgement of pluralities that often characterise communities. Thus, as noted by DiSalvo et al [112], the researcher should always work with great care not to reduce and essentialise participants or communities.

Yet, Lave and Wenger's view of CoP "stresses diverse forms of sense of belonging" where "boundaries can be vague" [100, p. 532], acknowledging that communities often emerged through sustained mutual engagement which evolve over time. As reported by Cox [100], quoting Gherardi, Nicolini and Odela:

> "Referring to a community of practice is not a way to postulate the existence of a new informal grouping or social system within the organisation, but is a way to emphasise that every practice is dependent on social processes through which it is sustained and perpetuated, and that learning takes place through the engagement in that practice" [142, p. 279].

2.3.3 *Discovering values through design*

Our investigations aim to gather a sense of the range of shared values and representations we might find across different communities of musical practice. Our intention is then to show the breadth of possible concerns and priorities musicians might (re)produce while imagining future instruments (Chapter 3), interpreting existing music technologies (Chapter 4) and making original interfaces (Chapter 5).

Within HCI, a number of approaches have been developed to elicit stakeholder views and values. Katie Shilton provides a thorough review of the constellation of theories and methods for surfacing values and ethics in technology design [327].

One of the most recognised methodologies for the translation of values into design choices is Value Sensitive Design (VSD). VSD was introduced by Friedman et al. [132] and it can be defined as "a theoretically grounded approach to the design of technology that accounts for human values in a principled and systematic manner throughout the design process" [135, p. 64]. A working definition of *value* within VSD is: "what is important to people in their lives, with a focus on ethics and morality" [135, p. 68]. Methods concerned with empirical investigations for

value discovery and representations include value scenario [379], value sketches [376] and semi-structured interviews [102].

Value-driven research is often concerned with the incorporation of broad ethical, environmental and social values (such as sustainability, privacy, democracy, inclusivity and accountability) into technology design [134, 354], aiming to design technologies that could help shaping better societies and improve quality of life [133].

In this regard, many researchers develop a sounding critique of early VSD approaches aiming to temper the universal notion of ethical and moral values [198]. As noted by Borning and Muller "the belief that there are universal values (from whatever source – God, evolutionary development, biological determinism, ...) has on occasion led to the further belief that a particular group, culture, or religion is the keeper of those values, and needs to impose them on others – with sometimes tragic consequences." [68, p. 1128]. Within a project values and priorities might then be negotiated amongst *parties* (e.g. designer and stakeholders) and they can also serve as explicit evaluation criteria [199].

According to this perspective, a key feature of value sensitive design is the sourcing and identification of potential values. One of the most common approaches to VSD involves a 3-phase process that supports the emergence, development and grounding of values [199]. This represents the full cycle of a values-led inquiry: from the process of early analysis to the development of the final product. Our research tackles this emergence phase, illustrating how we can support the discovery of values linked to the use and interpretation of music technologies.

The following chapters then relates to those VSD research that approach the emergence of *values in contexts* based on culturally-specific and participatory processes [68, 199]. In particular, we draw on the work of Le Dantec et al. which suggest a series of explorative VSD methods to foster "the discovery of and engagement with local expressions of values" [219, p. 1144]. Such approach foresees the empirical exploration of values as embedded into subjective perspectives and practices. Le Dantec et al. then understand values inseparable from lived experience as they both shape and are shaped by lived experience.

Although we do not claim to present anthropological research, the work introduced in the coming chapters relates to the attitudes and concerns linked to these qualitative works, whether to explore digital tools and their *culture of use* (Chapter 4) or to discuss the evolution of a musical interface through an autobiographical

perspective (Chapter 6).

More specifically, our investigation builds on a set of technology research concerned with sociology, anthropology, and cultural studies. Our approach to the discovery of values then aims to investigate knowledge and representations musicians develop through the direct, first-hand involvement with music technologies. In this regard, our methods are influenced by ethnographic and auto-ethnographic HCI contributions [117, 306, 110, 108].

An important source of inspiration for our work relates to *cultural probes* methods [137, 190, 342] which have been developed to scrutinise complex, socially-organised settings. Within HCI contexts, cultural probes are generally intended as packages of objects, questionnaires and exercises which encourage people to reflect on their experience in an open-ended fashion. These allows researchers to collect artefacts and data which are then exploited to better understand local cultures and inspire design interventions. The instruments introduced in Chapter 3 and Chapter 5 might be somehow interpreted as cultural probes, since they provided us with rich and varied accounts "of their beliefs and desires, their aesthetic preferences and cultural concerns" [137, p. 29].

Based on the relational and experiential framework outlined in this chapter, the methods adopted in this research heavily rely on hands-on manipulations of materials and tools. This practical explorations were conceived as playful group activities, ranging from small groups of 2 up to larger activities of about 30 participants. This enactive attitude partially derives from the influence Kristina Andersen's work had on this research.

Drawing from design and art practices such as embodied design [374], bodystorming [289] and dance choreography [211], Andersen considers the concept of *thinking with the hands*: "we use physical making as a way of thinking with our hands and then letting the resulting object support the imagining and talking about any underlying ideas" [13, p. 39]. The design work described by Andersen is in many ways inspired by the philosophical work of Dewey which stresses the centrality of practical experience for the formulation of thought itself:

> "[T]he philosopher like the carpenter, the physician and politician know with their habits not with their 'consciousness'. The latter is eventual, not a source. Its occurrence marks a peculiarly delicate connection between highly organised habits and unorganised impulses. Its contents or objects, observed, recollected, projected and generalised into princi-

ples, represent the incorporated material of habits coming to the surface, because habits are disintegrating at the touch of conflicting impulses. But they also gather themselves together to comprehend impulse and make it effective." [111, p. 182]

The value discovery exercises explored in this dissertation are meaningfully indebted with the Magic Machines workshops developed by Andersen. These can be framed as a set of strategies aiming to expose individual's visions and knowledge through the making of "not-yet existing" artefacts [14].

By taking rather literally Clarke's idea that "any sufficiently advanced technology is indistinguishable from magic" [12, p. 8], Andersen exploits the notion of *magical unknown* [15] to free participants' imagination; "a theatrical turn, which allows the users to explore how such an interaction with the real technology might be" [11, p. 632].

Based on this attitude the musicians involved in this research were indirectly invited to disclose their personal relations to technology by making musical artefacts which materialise their visions and concerns [10].

From a more general viewpoint, Andersen's attitude inherits the disciplinary and epistemological perspectives characterising *Research through Design* (RtD) [385, 69]. Over the last years, the HCI research community increasingly incorporated design practices to pursue research on technology and its contexts. Although RtD contributions might vary in methods and results, practitioners often agree in recognising the production and discussion of "artefacts" as a way to ground knowledge, explore hypotheses, understand contexts or inspire action [140].

As RtD work often looks at the arts and humanities to inform HCI inquiries, researchers often value the ability of the field to generate diverse, situated and reflexive outcomes [322, 165, 286, 306] – where the idea of *outcome* does not refer solely to the "end product" but rather includes design processes [293], material reflections [299] as well as people's use of the created artefacts [363]. These perspectives move away from the scientific paradigms and mitigate "expectations of creating extensible and verifiable theory" [140, p. 945].

2.3.4 *Doing research through art and fiction*

Alongside the critical and contingent attitudes that characterises RtD, in recent years, HCI research embraced a variety of approaches as diverse fields have been

brought into contact with their research practice [287]. Researchers are increasingly engaged with an inclusive and critical discussion of technology, mediating perspectives from the arts [103] and humanities [166].

This thesis examines the complex and multifaceted nature of contemporary musical instruments through a series of cheerful, creative and permissive design explorations. In this respect, our work situates close to fictional, speculative and ludic HCI approaches [118, 54, 361].

Design fiction has been defined as "the deliberate use of diegetic prototypes to suspend disbelief about change" [234, 52], and, within the HCI community, its origins are generally found in the work of Superflux [339], Dunne and Raby [118] and Julian Bleecker [49]. Researchers often refer to the notion of *diegesis* as one of the key features related to design fiction practices [55, 333]. For instance, Bleecker and Kirby introduce *diegetic prototypes*, stressing that design fiction artefacts exist within a narrative [210].

This implies an understanding of fictional objects as means for the creation of story worlds and discursive spaces [234]. These prompts might embody fears, desires and priorities within open-ended design spaces [55, 138]. Thus, the ambiguity that often characterised fictional artefacts often announces the generative power of these investigations [140, 53].

During the years design fiction has taken various forms including textual-visual "counterfunctional" artefacts [295], pastiche scenario [56] and material speculation [361]. An approach that particularly influenced our work is the one introduced by Mark Blythe et al. [55] where design fiction is exploited to generate fragile, cheerful and sometime naive design ideas. In this research, by fostering playful narratives and scenarios, fictional artefacts become useful prompts to acknowledge the complexity of design *problems* and the limitations of our *solutions*.

As mentioned in previous section, our work largely builds on Kristina Andersen's Magic Machines workshops [14]. These have been developed within a larger body of work exploring the making of open-ended fictional artefacts to materialise personal technological perspectives [12].

Following Andersen, our research combines "magical thinking" and "embodied making" to facilitate the emergence of subjective and unconstrained visions – i.e. narratives entailing makers' intentions, motivations and feelings. The generation of make-believes artefacts then allowed us to explore, interpret and compare assumptions and representations associated to musical devices.

Finally, the approaches to music technology research described in this thesis certainly pay a tribute to artistic/philosophical movements such as dadaism, surrealism and situationism. While planning our studies (see in particular the works presented in Chapter 5) we broadly looked at these cultural insurgencies; amongst them Pataphysics was undoubtedly the most inspirational.

Pataphysics is often introduced as *the science of imaginary solutions* [200]. Raymond Queneau declared that pataphysics "rests on the truth of contradictions and exceptions" [187, p. 5], and many leading pataphysicians have added definitions such as the *science of the particular* which aims to investigate *the laws governing exceptions* [201]. While celebrating human subjectivity and the multiplicity of things, pataphysics offers a severe and ironic critique of positivist thinking, a serious humour that "finds fertile ground in any mind that thinks the objective truths of empiricism at least demand a little playful tweaking" [187, p. 2].

Since the "apparent" death of its prime exponent Alfred Jarry in 1907, pataphysics has silently influenced a large part of western cultural production, including – directly or indirectly – academia and scientific research. Within the context of research dissemination, an example of such pataphysical attitude is the Ig Nobel Prize: an annual ceremony where actual Nobel Laureates award improbable but serious research achievements [17]. These prizes are intended to applaud unusual and imaginative research that makes "first laugh and then think" [1] as well as stimulate people's interest in scientific research such as medicine or engineering.

Out of the many *pata-musical* resources that inspired our work, we mention the *Museum of Imaginary Instruments*. Curated by Deirdre Loughridge and Thomas Patteson, the museum offers a collections of "fictophones" often existing as diagrams, drawings or written descriptions [236]. Loughridge and Patteson note that musical tools "take on physical reality that previously existed only in the conceptual space" [18]. This project stimulates reflections on the emergence and evolution of musical objects and the requirements, at once material and intellectual, they should have to be acknowledged as musical instruments.

The fascination with surreal, ironic and uncanny objects also exists in design contexts. Often mentioned in HCI domains, is the Japanese art of Chindogu, where a designer produces "un-useless" objects [55]. Unlike other absurd designs, Chindogu must physically exist (i.e. a concept should be translated into an artefact)

17 For instance, the 2019 medicine award went to Gallus et al. for collecting evidence that pizza might protect against illness and death, if the pizza is made and eaten in Italy - see 2019 Ig Nobel Prize Winners – last access April 14, 2023

18 See Museum of Imaginary Instruments – last access April 14, 2023.

and they must be, from a practical point of view, (almost) completely useless [208]. Often Chindogu solve one problem while creating other, larger problems – see, for instance, the Noodle Cooler: an electric fan attached to the chopsticks that cools noodles just before they are eaten. In this sense the object is not useless, but neither is it useful: it is *un-useless* [19].

The spirit of Chindogu was embraced by Sheridan and the .:thePooch:. collective who organised the first Chindogu Challenge [20]: "a kind of 'hackfest' for human-computer interaction academics with the purpose of challenging them to use an unfamiliar creative framework" [326, p. 253]. Due to its explicit affiliation with the HCI realm, this initiative was a main source of inspiration for our enterprise. Another influence was the Stupid Hackathon, started by Amelia Winger-Bearskin, a playful event where participants create tech projects that "have no value whatsoever" [21]. The work presented in Chapter 5 can been then considered as a variation of the Stupid Hackathon but with a focus on the design of impractical and unworkable musical devices.

Beside offering a glimpse on the diversification of critical positions we can find in design and HCI contexts [310], the references above outlined a variety of creative approaches to technology research. These attitudes and mindsets are fully embraced in this thesis. Accordingly, we attempt to engage the musicians involved in this research in creative, artistic and exploratory activities. This open-ended and generative approach allowed us to sidestep functional and technical practices and uncover cultural values and representations.

2.4 CHAPTER CONCLUSIONS

This chapter outlined the theoretical basis of our research which encompass ideas and approaches from a variety of fields. In Section 2.1 we attempted to provide an overview of the intricate techno-musical perspectives that we can appreciate in music technology contexts.

To drastically simplify, NIME is concerned with creating new instruments, principally but not exclusively using digital technology. The NIME community embraces certain cultural and aesthetic values (although with wide variance across practitioners) whose identity is the topic of ongoing conversation [156, 90, 270, 45, 271, 170]. Finally, NIME prides itself on its multidisciplinarity, including its

19 For a better understanding of Chindogu see The Ten Tenets of Chindogu – last access April 14, 2023
20 See the Chindogu Challenge organised by the *.:thePooch:.* in 2005 – last access April 14, 2023
21 For an overview of the first Stupid Hackathon - last access April 14, 2023

parallel roots in HCI and arts practice [250]. None of the three aforementioned statements is an inevitable consequence of any of the others.

This research does not intend to resolve longstanding debates about what values are (or should be) found at NIME. Rather, this thesis aims to support researchers in the process of unpacking the socio-technical intricacies that characterise musical interfaces and their contexts and critically challenge technology ideation and development.

What is currently missing in NIME research, we argue, are non-reductivist, generative, uncertainty-seeking and practice-based strategies for the discovery of the techno-musical visions inscribed into digital tools [71]. Following this attitude, our work aims to explore the tacit socio-material conditions that facilitate the emergence of certain music technologies from certain socio-cultural environments (and not others). We do not claim to uncover the entire spectrum of factors influencing the work of musicians and designers. Rather, this dissertation outlines a set of creative approaches for the acknowledgement of values and perspectives that avoid overly theoretical discussions and objectifying procedures.

Drawing on philosophy of technology and STS studies, we also introduced a set of arguments on the non-neutrality of technology, suggesting that, due to their countless inscriptions, digital instruments actively promote musical ends and values in ways that are qualitatively different compared to the constraints and affordances of traditional instruments. This perspective supports the research questions posed in this dissertation, highlighting the need to expand our critical abilities for the discovery of values in music technology contexts.

Furthermore, the observations articulated in Section 2.2 provide a viable theoretical framework for the scrutiny of the modalities through which digital tool and materials influence music technology practices. In particular, the *means become ends* and *quantity affects qualities* perspectives will be further considered and discussed in light of the research presented in the following chapters.

Finally, we reviewed the existing technology research which provides crucial points of reference for the studies presented in this dissertations. The selection of HCI and design work presented then illustrate key operative concepts and terms such as *value discovery* and *communities of practice*. Based on these considerations we can now intone: this research focuses on the discovery of values inscribed into musical interfaces and mediated by communities of musical practices.

Section 2.3 also introduced different approaches to design research which privilege artistic, open-ended and critical attitudes. The work reported in this thesis

then draws on these methods, adopting and re-interpreting them based on the different research demands and interests addressed in the various chapters. By moving away from classical design methods, we aim to advance the debate around the complex, interdisciplinary and multifaceted nature of contemporary musical instruments, thus questioning the assumptions and routines we sometimes encounter in academic and research areas through playful and creative design explorations.

3

ON MUSICAL CULTURES AND COMMUNITIES OF PRACTICE

This chapter is built on significant material from 'Making Up Instruments: Design Fiction for Value Discovery in Communities of Musical Practice' by Lepri and McPherson, originally published in the proceedings of the Designing Interactive Systems Conference, DIS 2019 [225] and 'Fictional Instruments, Real Values: Discovering Musical Backgrounds with Non-Functional Prototypes' by Lepri and McPherson, originally published in the proceedings of the International Conference on New Interfaces for Musical Expression, NIME 2019 [228].

The two studies presented in this chapter aim to examine how diverse musical backgrounds related to specific communities of practice influence the ideation of music technology. First, I introduce a design fiction workshop in which musicians active in different musical contexts are invited to imagine and sketch not-yet existing music instruments "as if by magic". This research provides a sense of the range of interests and concerns we might find across the various groups. The intention is then to explore the breadth of possible values and priorities in relation to different music cultures and practices, and by extension some processes by which values might be queried in other areas of SMC and HCI.

Second, I report on an online survey in which music technologists were asked to speculate on the background of the musicians who designed the fictional instruments. This follow-up study aims to gather further evidences of the presence of shared musical values in the musical prototypes created. In particular, it investigates whether observers with music technology experience can work out the background of the musicians involved in the design fiction workshop based on photos of the prototypes and a short descriptions provided by their creators.

3.1 BACKGROUND

Instrument makers envision for their instruments contexts (e.g. music venues and schools), aesthetics (e.g. genres and stiles) and behaviours (e.g. performance techniques). Likewise, by means of teaching, composing and performing, musicians

are influential vectors through which musical values are conveyed within communities. Different musical communities – linked to different technologies and practices – might then develop different values which shape the development and use of musical artefacts. As considered in Section 2.1, the NIME communities embrace an assortment of cultural values – with variance across practitioners – which might considerably influence the ways researchers envision and understand novel musical interactions [156, 270]. Typically, practitioners recognise the multidisciplinarity of the NIME field, including its parallel roots in HCI and arts practice [250].

This chapter examines the ways in which an individual designer might express their own values through making, and what cues an observer would then use to recognise them. The two studies introduced can be considered as value discovery exercises [220] involving design fiction [14] and community-based design methodologies [112].

The work detailed relies on design fiction methodologies [52]. More specifically, our research draws on the work of Kristina Andersen and it can be considered a variation of the Magic Machine workshops [14]. As reported in Section 2.3.4 design fiction has been defined as "the deliberate use of diegetic prototypes to suspend disbelief about change" [234, p. 210]. The narratives that an artefact conveys are not just about the imagined device and its functionalities, they rather contribute to "the creation of cultural objects, allowing them to act as prompts for a story we tell about ourselves" [10, p. 2]. The first study presented focuses on the exploration of cultural artefacts through crafting activities. The intention is then to identify shared musical values and investigate the modalities by which they might be transferred into a future technology. The follow-up study instead exploits the mock-up instruments as open-ended design spaces [139], thus taking advantage of the ambiguity that often characterised fictional artefacts to engage music technologists and allow them to freely interpret the artefacts' origins [140].

Section 2.3.3 examines a number of HCI approaches developed to elicit stakeholder views and values. Value-driven research is often concerned with the incorporation of moral and social values (such as sustainability, privacy, democracy, inclusivity and accountability) into technology design, aiming to design technologies that could help shape better societies and improve quality of life [133, 354]. On the other hand, various research has approached the discovery of stakeholders' values based on more culturally-specific and participatory processes [68, 220]. The works here introduced are oriented towards these kinds of socio-cultural investi-

gations, in order to discover patterns of experience and meaning-making related to the engagement with music technology [198].

The reflections introduced in Section 2.3.2 sought to provide the working definition for the notion of "community" used in the dissertation. The musicians involved in the design fiction workshop share specific musical backgrounds (learning and educational processes), instrumental expertise and ensemble practices. These elements are also situated in specific places and social gatherings (e.g. music schools, concert halls, clubs and festivals). Based on Anderson's contributions, we interpreted communities as requiring shared imaginaries, intended as sets of values and symbols common to a particular social group [17]. In this research, we are interested in both the sharing of interests towards specific aesthetics (e.g. musical genres) and in common legacies received from music traditions (e.g. influential musical contributions and narratives related to specific social groups and geographical areas).

Finally, our work has been inspired by various HCI research engaging with specific social groups. Participatory Design (PD) research often aims to work with and for communities by focusing on "the social constructs and relations of groups in settings" [112, p. 1]. Within the vast spectrum of community-based PD research, various research influenced the work presented in this chapter as they show similar sensitivities and overall goals. These include the fostering of cultural productions as a way to make public subjective views of first and second generation immigrant youth [48], and the mediation of stakeholders' values where digital technology was designed to support the experience of adults with severe intellectual disabilities in art museum [198].

3.1.1 *Research questions*

The studies introduced in this chapter address the following research question:

How can we discover shared values and assumption produced by different communities of practice in relation to new instruments?

In particular I ask:

- In what ways does the involvement with a community of musical practice shape the understanding of musical interactions?

- Given a novel musical instrument, to what extent can the musical background of its maker be identified?
- How do makers' musical background influence the design and interpretation of new DMI?

3.2 AS IF BY MAGIC WORKSHOP

Figure 3.1: People making things

This Section introduces the As If By Magic workshop, a hands-on activity in which musicians active in different musical contexts were invited to envision not-yet existing musical instruments. The purpose of the workshop was to produce cultural low-fi artefacts [10, 137] through crafting activities. As the workshop aimed to explore possible design spaces emerging from the musicians' subjectivity, it was conceived as an open-ended exploratory experience. The intention of outlining an open-minded setting also influenced the selection of materials provided: mundane and everyday objects.

3.2.1 *Workshop materials*

Figure 3.2 shows the materials mainly used in our workshops: cardboard, disposable cups, paper plates, masking tape, roll of twine, scissors, wire cutter, paper clips and pins, metal wire, plastic ball, elastic bands, straws and toothpick. The materials were arefully selected according to Andersen's referenced methodology [12, p. 93]. While choosing the materials, we avoided tool kits, electrical components,

sensors and software units. Most of the participants involved were not familiar with hardware and design tasks; the materials have been therefore selected to be perceived as not intimidating. Moreover, to support the creativity of the musicians we sought to bypass paradigms, uses and discourses linked to existing technology. It is not my intention to negatively label research that encompasses the design and analysis of toolkits for the development of new musical instruments (see [82] for a successful example of this approach). However, we would argue that any functional technology always embodies specific uses, intentions and meanings.

In sustaining this point, we refer to the notion of *perceived affordances* as introduced by Norman within the context of HCI. In a rundown, a design provides *clues* [284]. We avoided tool kits, electrical components, sensors and software units because of the affordances already present in the given technologies (as properties both related to the actual objects and dependant on culture, prior knowledge or expectations of the person). In line with this considerations, Kristina Andersen discourages materials with distinct acoustic properties (e.g. boxes and wood) as their usage risks to limit people imagination and inventiveness [14].

Based on this framework and Andersen guidelines, we privileged mundane and everyday objects. By sidestepping tools and materials directly linked to existing functionalities, we aimed to free participants and facilitate the emergence of individual values and purposes.

Figure 3.2: Curated material selection for the As If By Magic workshop.

3.2.2 *Participants' background*

The various workshops involved 29 musicians: 20 male, 9 female, aged between 16 and 65 (average 32). After recruitment, detailed information on each participant's instrumental background, musical practices and aesthetic preferences were collected through an online survey – see Section 3.2.4. As mentioned in Section 2.3.2, We are aware that the term *community* is often difficult qualifier. Professional musicians are often engaged with two or even three different musical communities, thus dealing with different practices, genres, aesthetics and styles. Furthermore, in addition to traditional instrumental skills, 9 participants declared to have music technology expertise (i.e. a strong multidisciplinary background). However, for each participant it was possible to identify a community of practice and two genres (primary and secondary) in line with the various backgrounds and music activities declared. The participants involved in the workshop are musicians active in the following musical communities:

- **Ethnic**[1] - Afro-Cuban 2 musicians, Middle-East 2 musicians, Balkan 2 musicians, Italian-Folk 1 musician;
- **Classical** - Classical orchestra repertoire 6 musicians, Contemporary Classical / New Music 2 musicians;
- **Electronic** Electroacoustic 5 musicians, IDM (Intelligent Dance Music) and Alternative 3 musicians;
- **Improvisation** Free Improvisation (electronics excluded) 3 musicians;
- **Rock, Pop and Jazz** - Rock and Pop 2 musicians, Jazz 1 musician.

3.2.3 *Workshop facilitation*

Andersen's original workshop aims to encourage participants in the direction of thinking outside the box in order to promote a shift outside their normal way of thinking about music and musical instruments. The workshop facilitator should thus carefully balance two parallel processes: the promotion of novel ideas while letting participants follow their trains of thought without interference. Rather than provoking original and disruptive design ideas, this work focuses on the

1 In this context we use the term 'ethnic' as shorthand for specific regional musical traditions rooted in the history of a particular community, while acknowledging that the other musical communities in this study may also be considered to exhibit these properties.

emergence of existing musical values and instrumental concerns. We therefore approached the task of conducting the activity with the intention of exploring latent assumptions on music technology. We are not interested in the novelty *per se*; instead we exploit the workshop to elicit participants' internalised musical values that influence their expectations of the nature of musical instruments.

Drawing on Andersen's approach, the terminology used while introducing the workshop tasks have been carefully pondered. The word *magic* "is used deliberately to introduce the notion of new, powerful and unknown" [12, p. 39]. Instead, the word *machine* evokes something rather undefined associated to the ideas of technology and physicality. The words *instrument*, *design* and *technology* are avoided in order to prevent participants limiting themselves to ideas they already consider possible with current technologies. The language used aims to "open up the query beyond what it is adjacent to our current technologies" [12, p. 35].

During the As if By Magic workshop the musicians engage with the activity of sketching a *magic machine* that should address performative features or sonic possibilities defined by the participants themselves. The overall duration was around 1 hour, depending the number of participants. After a brief introduction (welcoming and presentations) the musicians are provided with two prompt activities: (i) write down a relevant aspect of your instrumental musical practice (ii) draw one sonic element of a music you particularly enjoy playing or listening to. The aim of the prompts is to situate the work within the musical practice of each participant, i.e. instrumental and aesthetic outlooks. The prompt activity is an achievable and fast task that frames the upcoming design phase. Figures 3.3 3.4, 3.5 are examples of participants' drawing prompts.

The musicians are then asked to use the available materials to build the *machine* that addresses the prompt. Thus, participants are invited to build mock-up instruments that work *as if by magic*. The contents of the prompts must be translated into an imagination of the device that privileges, supports or produces them. Once the group has finished building the *prototypes* the facilitator invites the musicians to present their machines and explain its functionalities (e.g. how should the machine be played?). After each presentation, the facilitator invites the whole group to share comments, impressions and ideas.

This activity takes the form of a group discussion and it aims to explore possible divergent interpretations of the artefact and the degree of agreement in regard to the ideas proposed. During the first phase of the workshop, we provided general instructions and clarified requirements while taking care not to suggest ideas. For

group discussion, the facilitator asks open-ended questions, often inviting participants to elaborate on phrases the participants themselves previously said. Overall, we ran 8 workshops with an average of 3 participants per workshop. The scheduling of the activities was organised to group together musicians belonging to the same communities of practice, with the aim of eliciting shared values and concerns within each community.

Figure 3.3: Examples of abstract sound and music drawing prompts.

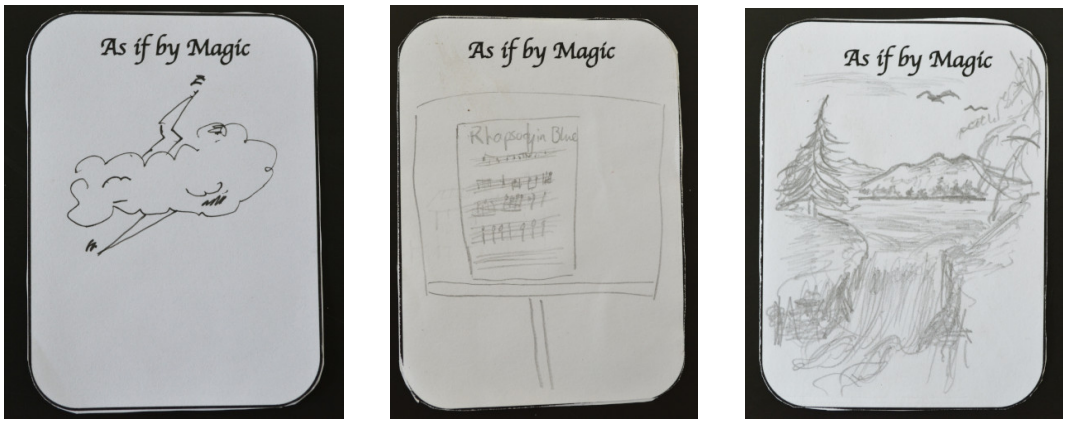


Figure 3.4: Examples of figurative drawing prompts, including a musical score and nature elements.

Figure 3.5: Examples of drawing prompts representing sound/music in time or space.

3.2.4 *Data analysis*

The analysis of the data focused on establishing connections between the workshop results and the cultural heritage of the musicians involved. More specifically, once we were able to identify analogies within communities, we aimed to look for theoretical explanations in relation to the similarities and differences spotted between the groups. This is based on the idea that cultural phenomena can be better understood when they are compared in relation to contrasting (meaningfully different) cases [77]. This process led to the identification of different perspectives related to the interpretation of not-yet existing technologies – see Section 3.2.6.

The analysis included both the workshop outcomes (i.e. mock-up instruments and interviews) and the information gathered through the online survey. For each participant, we were able to gather information related to (i) the instrument(s) played and the year of practices, (ii) the genres of music studied and currently practiced, (iii) aesthetic and stylistic preferences (i.e. favourite genres and influential musicians or ensembles). These data related to the musicians' background were organised in a set of variables:

- **Main Genre** - Jazz/Blues, Classic, Rock, Soul, Middle East, AfroCuban, Balkan, Electroacoustic, New Music, Free Improvisation;
- **Second Genre** - Classic, Electronic, Funk, Alternative (misc), World music, Pop Rock, Middle East, Europena Folk, Ancient, Jazz, Free Jazz, New Music;
- **Main Instrument** - Guitar, Bass guitar, Plucked Ethnic, Percussion Ethnic, Trombone, Flutes Ethnic, Piano, Electronics, Karlax, Cello, Flute, Violin, Saxophones, Voice

- **Year of instrumental practice** - Ranging from 2 to more than 20;
- **Second Instrument** - Bass guitar, Modular Synth, Electronics, Percussions Ethnic, Piano, Marimba, Plucked Ethnic, Guitar, Theremin, Voice, None;
- **Instrument Design Expertise** - High, Medium, Low.

Regarding the level of instrument design expertise, almost half of the musicians involved (12 participants) did not have specific knowledge and experience related to instrument design. On the other hand, 10 participants declared to be involved in the development or modification of instruments or technologies for music performances. The remaining participants declared to have had some experience in repairing existing instruments or building simple music interfaces.

Both prompts and machines were documented (i.e. pictures) for later analysis. The group discussions and presentations were audio recorded and manually transcribed. These data were analysed following a thematic analysis methodology [311] characterised by a data-driven (inductive) approach: looking for patterns, similarities and correlations while analysing the data [105]. The various codes were collected in a codebook which has been systematically updated and refined. The various codes were organised by categories: groups of codes that shared specific elements and features.

We conducted five iterations of coding, and only once the code book was established did hypotheses or theories emerge. The method adopted (from open coding to category formation) forced us to critically look at data through many lenses and each concept earned its way into the discussion by repeatedly being present in the data [178, 99]. The full process of data analysis can be summarised in the following steps:

- Open coding - formation of initial codes from the interview data. We read the data in order to become aware of (i) the most present words and phrases and (ii) the information that seems to be of importance or interest to the research;
- Codebook - collection and re-assembling of initial codes. The codebook is constantly updated and refined at each coding iteration. Each code is made of a label, a definition (with inclusion and exclusion criteria), and examples. The codebook was developed to: (i) identify central phenomenon (e.g. representation of musical activity); (ii) explore causal conditions (e.g. presence

of puppets and figurines representing musicians); (iii) identify context and intervening conditions (e.g. musician declarations on the artefact);

- Category emergence - hypotheses (i.e. themes relevant to specific issues) were formulated using the codes defined. This process entailed the selection of the core themes, systematically relating them to other themes and validating those relationships. Codes relate to a common theme were grouped together through a criterion of higher order commonality;
- Concepts - grouping categories to find yet higher order commonalities for the emergence of high-level ideas.

3.2.5 *Findings*

This section introduces the results of our analysis. According to the approach proposed by DeCuir-Gunby et al. [105] the various themes identified are presented with a short description and examples from the interview data.

A summary of the analysis's thematic headings is presented before describing the results in more detail.

- Artefact Interpretation
  - Representation
  - Non functional prototype
  - Functional artefact
- Technological References
  - Traditional instruments
  - Current electronic music technology
  - Not existing music technology
- Expression and Perception
- Musical Aesthetics
- Body Interactions and Technological Agencies

Artefact Interpretation

One of our main findings relates to the participant understanding and interpretation of the produced artefacts – i.e. the nature of the objects designed. It was possible to identify three main approaches to the presentation and interpretation of the various mock-ups: functional artefact, prototype and representation.

REPRESENTATION The artefact is described as a representation of a musical activity (e.g. playing or listening music), see Figure 3.6. The artefact components are often associated with elements related to the targeted activity (e.g. people, objects, spaces or actions). The artefact does not imply any functional element and it is not linked to the ideas of machine, tool or instrument. These mock-ups often include puppets, dolls or figurines. The artefacts can also represent a more abstract idea (e.g. notion of music) or a state of mind (e.g. intimate and focused condition achieved while playing). This approach is rather common within the classical and ethnic communities, and nearly absent in the other groups.

> **P14**[2] (classical) - *"So, mine is not exactly a musical instrument.. it is more like a representation of music.. and I did represent the orchestra."* Figure 3.6 – **P7** (classical) - *"This would be the musician, and this would be the audience.. and so the elastic bands are the connection between the musician and the audience.."*

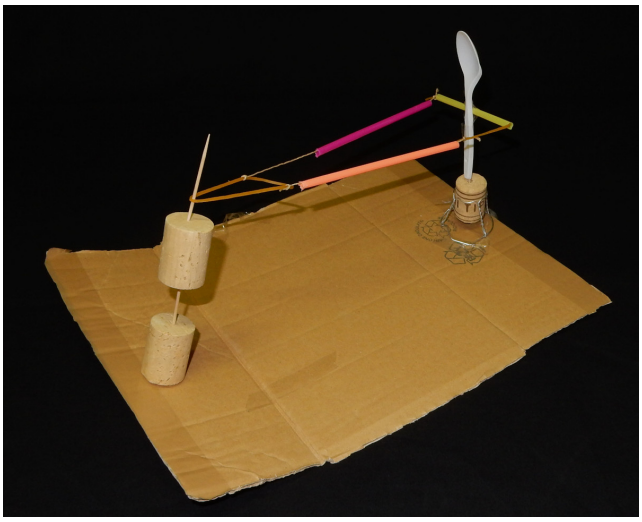


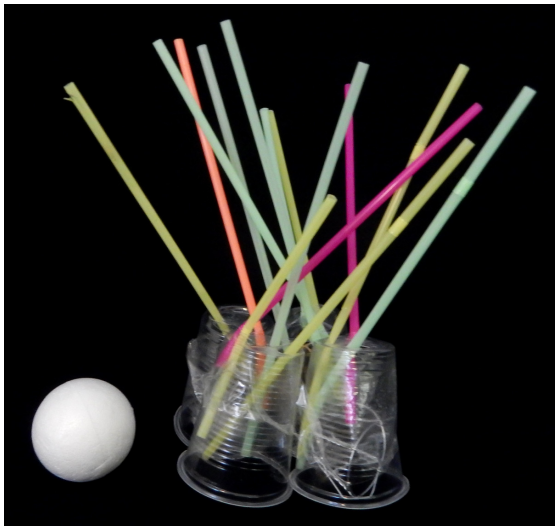
Figure 3.6: Example of artefact representing a musical activity – *Conductor and Orchestra*.

NON FUNCTIONAL PROTOTYPE The artefact is introduced as a model for a potentially workable instrument, see Figure 3.7. Although there might still be abstract or undefined elements, the makers tend to associate specific functions to specific parts of the artefacts. Moreover, the participants might evaluate the model in terms of plausibility (e.g. considering scale and range). In order to describe the

2 Participants are quoted using labels for anonymity (e.g. P1) followed by the musical context in which they are mainly involved in.

prototype, the designer might refer to: modalities of input, interactions between the artefact elements, structural or aesthetic elements, different versions of the same object. This type of artefact is prevailing within the electronic music community but it can also be found amongst classical and pop-rock-jazz musicians.

> **P12** (classical) - *"The air should go through the tubes, which have different timbre and frequencies, because they are made of different materials and different lengths.. so each of them is conceived for a type of sound"* Figure 3.7a



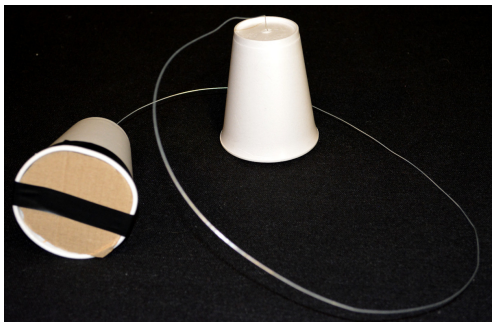
(a) *Corpo Souno* – an organ inspired instruments with tubes filtering the air.

(b) *The wheels* – a wheel based mechanical machine for the generation of polyrhythms.

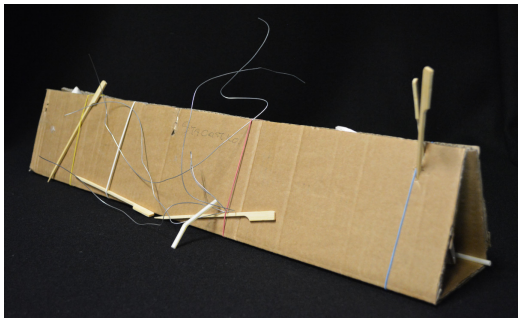
Figure 3.7: Examples of artefacts as prototypes of potentially workable instruments.

FUNCTIONAL ARTEFACT The musician builds an artefact that can actually make sound (see Figure 3.8), although this was not required by the workshop instructions – i.e. make "as if by magic". Most of these objects are intended literally as functional and often a proper demo showcased by the participants (eventually playing the instruments together as an improvised ensemble). In some cases, musicians apply basic instrument design knowledge (e.g. making a reed out of a straw) as an easy solution to the workshop task. This happened 3 times with ethnic musicians. Free improviser and electronic musicians were instead more interested in the actual exploration of the sonic possibilities of workshop materials.

P4 (impro) - *"You just have the reaction of the elastic bands.. you move these around.."* Figure 3.8b – **P13** (rock-pop) - *"I was trying to make a certain sound with the things that are available to me.. so I was like what can I do with these? It's like a proper sound!"* Figure 3.8a



(a) *Personal Shaker* – connected cups filled with materials that only the performer is able to listen to.



(b) *Stochastico* – percussive instrument equipped with many different tools and materials.

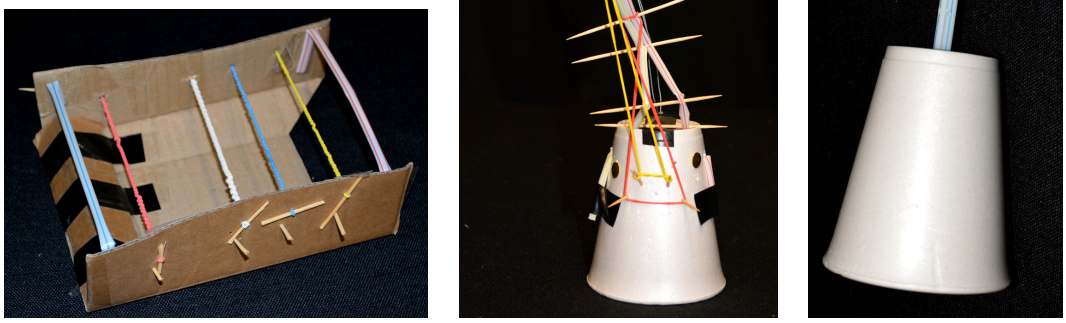
Figure 3.8: Examples of functional musical artefacts.

Technological References

Further elements emerging from our workshops are the analogies with familiar musical tools. While introducing the artefacts, the musicians tended to discuss the objects in relation to traditional instruments or current music technologies. However, ideas and designs not easily associable to actual music performance devices are also introduced.

TRADITIONAL INSTRUMENTS While analysing the presentations, it is possible to identify direct analogies to traditional instruments (e.g. classical orchestra or ethnic instrument) or traditional playing techniques (e.g. air emission, bowing, singing, plucking) – see Figure 3.9. Moreover, the artefacts themselves often resemble features clearly suited to the Hornbostel & Sachs original classification [358] (i.e. electronic instruments excluded). Apart from electronic musicians, all the groups generously refer to traditional instruments.

P22 (ethnic) - *"The Egyptians call it 'Mismar'.. the idea was [to build] a wind instrument broadly from this family"* Figure 3.9c – **P2** (jazz) - *"I'm gonna call mine Antenna Lele.. it has a neck then you can fold in several parts to get different notes.."* Figure 3.9b



(a) *Bands in a Box* – a string-based instrument inspired by the bass guitar.

(b) *Antenna Lele* – guitar like instrument with bendable neck.

(c) *Flute* – a double reed artefact inspired by Middle-East wind instruments.

Figure 3.9: Examples of artefacts inspired by traditional instruments.

CURRENT ELECTRONIC MUSIC TECHNOLOGY Musicians also tend to provide references to existing electronic music technologies and instruments, see Figure 3.10 – e.g. synth, sampler, sequencer, drum machine, laptop and software instruments. These are generally not easily classifiable using the Hornbostel & Sachs original system. Allusion to existing techniques and tools used in sound and music computing contexts (e.g. representation and retrieval of audio data or digital sound processing techniques) were also reported. Interestingly, within our groups, these references are the least frequent. As expected electronic musicians were the most active in mentioning this type of technology. However, regardless the musical community, participants with a music technology background tended to include current music technology in their descriptions.

> **P1** (electronic) - *"It looks kind of like the Laetitia Sonami thing.. built at STEIM right? so the Web.."* **P6** (classical, working in a music technology lab) - *"This is like a programmable instrument.. either it can take some input and then play it by itself or it records what do you have played and output some MIDI files or OSC"* Figure 3.10

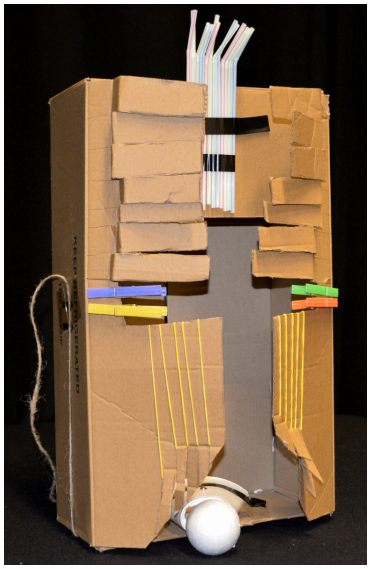


Figure 3.10: *The Practitioner* – programmable synthesiser/sampler which combines many different modalities of input (keyboard, guitar and trumpet) and supporting wireless, OSC and MIDI comunication.

NOT EXISTING MUSIC TECHNOLOGY The artefact is introduced as a not-yet existing technology (not necessarily electronic) or technique for music performance – see Figure 3.11. These could be completely imaginative or related to objects not belonging to music performance contexts. Within our groups, electronic and improvising musicians seemed to be the most keen to envision disruptive instruments that tend to step outside the borders of current technology.

> **P28** (electronic) - *"The idea of making this thing, that is between a fishing hook and a bolas.. maybe it would be nice to have an instrument that could throw things.."* Figure 3.11

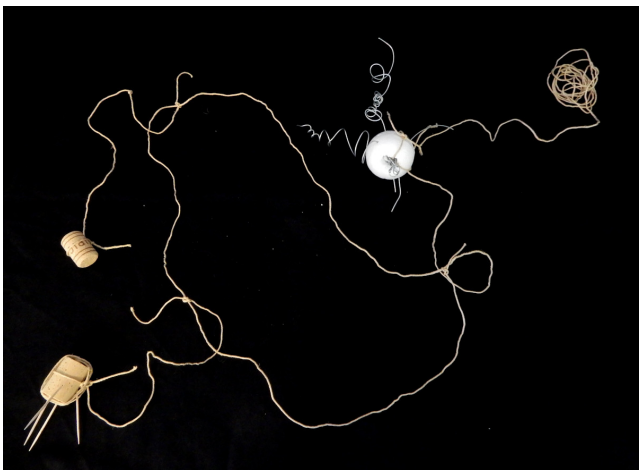


Figure 3.11: *Sonic Alarms* – wire based instrument for upper and lower limbs

> **P11** (electronic) - *"The problem here is that this instrument is a one-shot instrument, you can use it only one time.."* – **P3** (impro) - *"It makes me think of like a really badly made spaceship."*

Expression and Perception

Our musicians often used the mock-ups to talk about the act of communicating with listeners and stimulating feelings through sound. Emotions, then, might belong to the audience as well as to the musicians.

> **P14** (classical) - *"Even if it is not very easy to represent.. it is there.. the conductor passion is what moves and transfer everything to the orchestra.."* Figure 3.6

The perception of music and sound it is also an emerging theme. The act of listening is often considered as a fundamental ability that musicians must constantly develop. The artefacts might support the abilities of listening and feeling both yourself and the others (e.g. audience or ensemble members). Thus, the idea of feeling inner and outer musical worlds is crucial and abilities such as focus and sensitivity are important elements often embedded into the fictional instruments.

> **P20** (ethnic) - *"This is something that amplifies listening abilities.."* – **P16** (folk-ethnic) - *"This element is related to the perception of sound, meaning and emotion.."*

These concerns are generally distinctive of the classical, ethnic and pop-rock-jazz groups. The idea of *expression* intended as *moving* people through the music produced by the instrument was a recurrent topic in these communities. Moreover, these concepts were sometimes linked to the interpretation of a *repertoire* that is culturally grounded and codified.

> **P14** (classical) - *"One of the first thing I thought about is Rhapsody in Blue.. the piece we are playing with the orchestra.."* Figure 3.6 – **P2** (jazz) - *"That's related to a MIDIfied representation of a Jazz standard I am listening a lot lately"*

On the other hand, electronic musicians and free improvisers tended to manifest compositional interests and the use of the term *expressive* would typically refer to the possibility of exploring and manipulating sounds.

> **P9** (electronic) - *"My instrument basically allows for different expressive possibilities.. it allows for the possibility of creating different timbres.. rubbing, impulsive and emission.."*

Musical Aesthetics

As hoped, many subjective preferences on musical aesthetics and stylistic taste turned up. Classical and pop-rock-jazz musicians mainly described the imagined output of their instruments in terms of music theory: notes, pitches, rhythms, dynamics and polyphony. The sonic qualities foreseen were mainly associated with traditional instruments with allusions to rock-pop-jazz ensembles or to orchestral sonorities.

> **P2** (jazz) - *"I wanted an instrument that was able to play single notes, melodies and harmonies but with lots of flexibility.."* Figure 3.9b – **P24** (classical) - *"I guess it's a sort of like organ sound that I have in mind.. you could actually be operating something quite chordal altogether and moving quite polyphonically.."* Figure 3.7a

While introducing musical ideas, the notion of timbre was predominant within the electronic group. The alleged sounds produced by the mock-ups were often described in relation to physical behaviours (e.g. interacting objects) relying on acoustic and physical principles. Moreover, mathematical and scientific notions often drove the musical and compositional imaginations.

> **P1** (electronic) - *"I've been thinking about how to build an instrument, an acoustic instrument, that only outputs prime number frequencies.."* – **P27** (electronic) - *"I like the sounds of the rain like granular that start from nothing and arrive to everything.."* – **P9** (electronic) - *"this sums up the different expressive possibilities: rubbing, impulsive and emission.."*

Similarly, improvisers were interested in using the artefacts to navigate sonorities and explore musical ideas. However, it was possible to identify two main differences from the electronic group. First, rather than starting with some compositional idea in mind, improvisers tended to build their instruments from scratch. Second they tended to emphasise the importance of feeling sounds and materials while composing them.

> **P3** (impro) - *"I think it's plucky both in nature and in personality.. you're immediately in this funny realm of something that sounds quite like fakely.."* – **P8** (impro) - *"Being grounded and open enough so that the voice emerges as if by itself.."*

Body Interactions and Technological Agencies

In regard to the instrument-body relationships we were able to recognise different trends. Various musicians, often classical and pop-rock-jazz, tended to specify how to control specific artefact elements with specific body parts, often focusing on hand gestures and comparing these to traditional playing techniques. Ethnic musicians tended to have very similar concerns but, in addition, they often mentioned the possibility of having their instruments reacting to external sounds (as if able to resonate with the external world).

> **P24** (classical) - *"The way you alter the sound would be similarly to the way that the French horn alters the pitch.."* Figure 3.7a – **P17** (ethnic) - *"It receives vibrations and transforms them in itself.. expanding them, like it resonates with other sounds.."*

Electronic musicians instead often referred to gesture and control in a variety of ways. Besides hand gestures, full-body interactions were also considered. Gestures were sometime directly envisioned in relation to potential sounds, almost transcending the physical interaction to focus on the sonic dimension. Furthermore, this group tended to introduce notions such as autonomy and unpredictability. Thus stochastic and semi-predictable behaviours were often included into the instrument conception.

> **P9** (electronic) - *"I'm interested to explore gestuality.. compositional gestuality.. as this is a creative gestuality, a gestuality that brings to build the sound through the material"* – **P15** (electronic) - *"It would create a rhythm.. but it would always have slight differences"* Figure 3.7b

Finally, often driven by an open-ended and loose approach, improvisers were often interested in combining the materials provided in order to explore their sonic potential. In this sense, we could identify a fluid approach to the assemblage of physical elements, where parts could be easily exchanged or removed without necessarily resolving into a definitive structure.

P8 (impro) - *" I thought well maybe it just needs to remain loose.. It's an open instrument in the sense that open to things that can happen.."* Figure 3.8b

3.2.6 *Workshop discussion*

Our findings revealed several sources of influence on participants' artefacts, including musical aesthetics, performative attitudes, and prior experience with music technology. In an effort to outline the various themes previously introduced, this section considers three perspectives integrating the values emerging from the work of participants.

Recasting tradition: instrument-oriented values

While analysing the processes behind the innovation of classical musical instruments, Bijsterveld and Schulp introduce the notion of *recasting tradition* [43], arguing that successful innovations are characterised by design moves that readjust tradition. Thus, in the context of instrument design, a successful approach is to introduce *go-between* elements that can link strong cultural heritages (e.g. instrumental features or orchestral culture).

By looking at the workshop outcomes it is possible to associate this idea across multiple communities. These artefacts are often based on the principle of preserving key features of existing instruments while recasting others. A clear example is the *Antenna Lele*: a guitar-like instrument with a bendable neck that can be used to "shape melodies and harmonies" while playing (Figure 3.9b). This tendency diverges from the simple re-purposing of existing instruments due to the introduction of specific innovative elements that expand or alter the musical possibilities of the instruments. Another example of this approach is the *Personal Shaker* (Figure 3.8a: an altered traditional percussive instrument for private music practice and enjoyment.

It was possible to observe various instances (11) in which participants made instruments which resemble or are inspired by instruments they themselves play. Amongst the musicians whose first instrument was guitar (or similar plucked string instrument), 5 out of 9 produced artefacts with similarities to plucked string technique. Likewise, 3 of 4 wind players made simple but literally functional wind instruments using straws; all were ethnic musicians with instrument design expertise. Furthermore one pianist, one singer and one electronic musician made instru-

ments connected to their practice – respectively, a mock-up with keys, an artefact which involves the voice, and an interpretation of the Karlax MIDI controller.

Musical motions: communication-oriented values

Tom Mudd [274] examines two different perspectives on musical interaction: *communication-oriented* and *material-oriented* approaches, noting that "communication-oriented perspectives tend to foreground the agency of the human, whilst material-oriented perspectives draw attention to the agency of the technology" [p. 123]. The communication-oriented approach is often supported by embodied music cognition with the instrument behaving as a *transparent medium* for human intentionality: "transparent technology should give a feeling of non-mediation, a feeling that the mediation technology disappears when it is used" [223, p. 2].

In this investigation, communication-oriented values manifested in two ways: (i) the creation of abstract representations which essentially are about communication itself and (ii) the design of prototypes often intended as transparent technology for communication oriented processes. Examples of the first case include artefacts representing the orchestra and the conductor – see Figure 3.6 or representations of the listening process. The second case includes functional prototypes of instruments through which specific body parts will manipulate well-defined musical elements (e.g. pitch, rhythm); in Mudd's words, these suggest "a sense of control, in order to tame the instrument and ensure that it accurately transmits the musician's intentions ... The subtleties of the sounds produced are manifestations of a performer/composer's whim" [274, p. 128].

The first type occurred manly amongst classical and ethnic musicians, while the second occurred in these communities but also amongst pop/rock/jazz musicians. Both tendencies are generally *situated* in specific performative settings, e.g. considering the interpretation of a repertoire and the act of communicating to the audience or with other musicians.

In dialogue with technology: material-oriented values

Various NIME research highlighted that within much of the NIME and HCI literature, there exists a tendency toward communication oriented values, e.g. [154, 274]. Moreover, such mindset has been critiqued as it risks to promote a reductive conception of DMI design and evaluation [156]. By carefully analysing the work of participants it was possible to identify a contrasting *material oriented* approach which characterises the work of many NIME practitioners – for a more thorough

discussion of this topic refer to Section 2.1. An approach that sees technology as "a necessary and creative mediation that can be a source of ideas itself rather than simply a means for their transmission" [274, p. 123].

In this research, members of electronic and improvisation communities tended toward material-oriented values, expressed in two ways: first, through making functional artefacts focusing on the exploration of the literal sounds of the everyday materials (an approach found mainly in the improvisation community); and second, through nonfunctional prototypes accompanied by topics of discourse such as compositional metaphors [275], sonic exploration and artefact agency or autonomy.

As discussed in Section 2.1, an open debate in the NIME community concerns to what extent the use of computing technology rather than acoustic tools enables or even *demands* a material-oriented approach [239]. In other words: if material-oriented interaction is a value of NIME, is this because of its use of technology, or in spite of it? Some useful reflections emerge from this work: first, the improvisers involved are not primarily music technologists, yet they still show material-oriented values. Second, various participants (7) with a strong music technology background, but not involved in experimental music practices, expressed values which can be considered as communication-oriented in nature. Collectively, this suggests that the dividing line between approaches is not established by affinity for particular technologies but a shared cultural heritage – e.g. experimental and vanguard attitudes linked to the work of influential musicians of the mid-20th century.

Methodological considerations

In a sense, the "magic" element of Andersen's workshop is its effectiveness: the method simply works. At each iteration of the activity, it has been surprising to see how musicians get immersed into the creative process. Through the first task: "draw a sound", participants are prompted to retrieve a very personal musical vision which then functions as a creative boost. This is one of the most delicate moment, where the facilitator usually receive questions about the nature of the task. The coordinator is then confronted with the difficult task of answer in an open yet confident way, thus trying to address participants' needs to understand what's going on, without narrowing down the range of potential outcomes – e.g. providing too specific examples of sound-illustration affiliations.

It is not relevant if they are not able to rationally explain in detail their drawings. Rather, it is more important to second the fact that they "know what it is" and they can refer to it as a steady element grounding their work. The facilitator has the responsibility to welcome and back up the outcome of this first step by showing a genuine interest and asking open questions about the prompt. In particular, we found useful to invite participants to share their drawings with the group so that each vision is considered, possibly with positive feedback by the facilitator, and somehow "authorised".

Once the challenge of drawing a sound has been accepted and completed, the next step of the workshop smoothly unfold. Indeed, in our workshops, we could often see that when musicians are asked to build their magic machines they simply start doing it, typically without questioning the task. Participants' focus is in this phase particularly high and they tend to immerse in the exploration of the materials provided.

The crucial role of materials and the possibility of conducting research trough a material lens are established matters within the design and HCI communities [304]. In that respect, while designing an activity such as the one here presented, researchers should carefully choose the workshop materials. From our viewpoint, a different selection of materials (e.g. including more pliable and flexible materials like play-doh or fabric) could equally work, as long as the these elements would keep those mundane and ordinary qualities that characterise the materials introduced by Andersen [12].

Our choice of materials largely followed Andersen's guidelines. We acknowledge that the materials used in our workshop are characterised by specific perceived affordances. Indeed, we would argue that any selection of materials, in its own way, would inevitably influence the design process. However, for our purposes, the most important factor is that our materials did not embody one specific musical purpose or aesthetic. Andersen avoids the selection of functional or "too reactive" materials (e.g. elastic bands and magnets) as well as objects which might resemble screens and buttons [14]. This because, despite their everyday quality, these kind of materials might suggest features associated to existing musical instruments and therefore limit the emergence of personal and alternative visions. Since the goal of our workshops was not solely related to the generation of novel design ideas but rather an investigation of cultural concerns and priorities, we did not take such a strict approach.

Notably, materials that might have instrumental associations were not interpreted that way by the majority of our participants. This might suggest that the evocative power of such materials influenced specific sub-groups of musicians. We indeed noticed that mainly guitarists made plucked string instruments featuring elastic bands, and *only* wind players made wind instruments using straws. This highlights the influence that instrumental practices have on musicians' imaginations, lending support to theories that the instrument shapes how the musician thinks [281].

When participants are making their magic machines, there is usually no need for intervention from the facilitator, although occasionally single people might need some hints or encouragements. Overall, the main task of the workshop leader is to keep track of time, and communicate some minutes in advance that the working session is about to finish. Despite the playful vibe of the workshop, the making of magical machines can be a difficult and intense process, by the end of which participants might manifest signs of fatigue. On the other hand, at this point, it is often possible to perceive a general sense of accomplishment as participants somehow start to understand what the outcomes of the activity are.

In the final stage, when the magic machines are presented to the group, we noticed that inviting participants to give a name to their artefacts helps them to elaborate on their work and indirectly disclose about their own instrumental views and musical values – e.g. asking the questions: "why did you gave it this name?" or "could you explain what does this name means?". Once again, the idea of naming the artefact comes from Andersen, and it is in turn borrowed from theatre improvisation practices as well as design brainstorming techniques [12, p. 46-57].

Finally, on a more personal note, I wish to highlight the fact that I experienced the workshop a few times as participant when I was studying with Kristina Andersen. To be previously involved as a participant greatly helps to lead the workshop as facilitators can more easily identify the feelings and fears of musicians and therefore better guide the activity to accommodate them.

3.3 MAGIC MACHINE SURVEY

This section introduces the Magic Machines survey, a follow-up study in which music technologists were asked to speculate on the background of the musicians who designed the instruments created during the design fiction workshop. This

research examines how, while analysing both the mock-ups and the discourses related to their functioning and purposes, music technology practitioners were able to discover the communities of musical practices – and some of their shared values – linked to the instruments' makers.

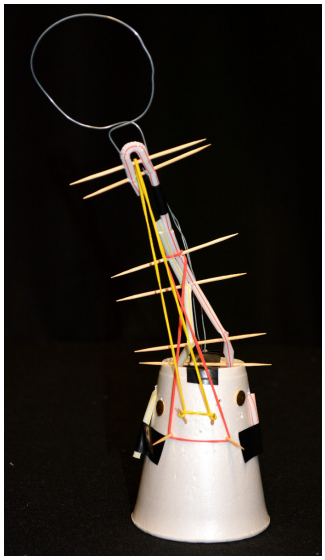
3.3.1 *Artefact selection*

Six prototypes were selected based on both the physical properties of the objects and the musical background of their creators (Figure 3.12). This selection aimed to present participants with a relatively broad set of musical backgrounds, covering different musical styles related to particular community of practices (i.e. diverse aesthetics and educations as well as instrumental expertise and ensemble practices). Some of the chosen mock-ups and prototypes resemble existing instruments, others feature instead new and disruptive design ideas. The following artefacts, identified along with the background of their makers and their intended functions, were included:

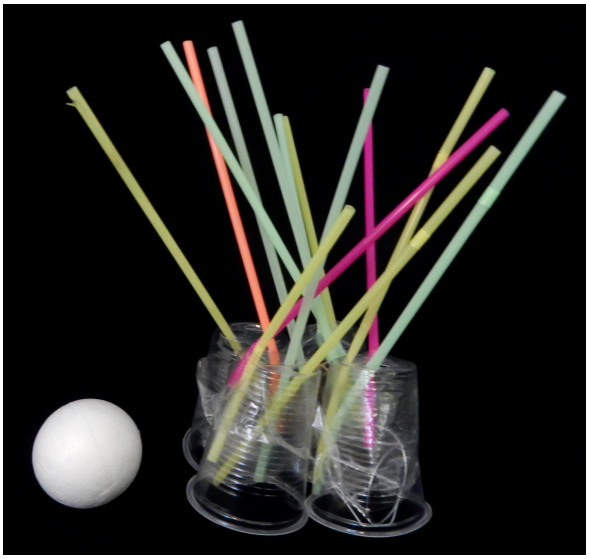
- **AntennaLele**: jazz - guitar (and bass) player with a strong engineering and sound and music computing background - ukulele-like instrument with a bendable neck that can be used to *"shape melodies and harmonies"* – Figure 3.12a;
- **CorpoSuono**: classical - keyboard player with interests in contemporary composition and a few experiences in the use of technology for music performance (e.g. synth) - organ inspired instruments with tubes filtering the air that can produce complex timbre – Figure 3.12b;
- **Plucker**: classical - guitar player with no experience in music technology and instrument design - wearable (glove like) polyphonic instrument with inside strings to be manipulated with one hand to control pitches and volumes – Figure 3.12c;
- **NonStopSound**: EDM - producer and performer of alternative electro-pop music with a background in music technology and expertise in instrument design - playful instruments based on a box containing a plate and two balls, sounds are by tilting the box making the balls and plate interact with each other – Figure 3.12d;
- **SonicAlarm**: electroacoustic - composer and performer interested in contemporary electronic music and improvisation with a strong engineering background, interface design skills and no instrumental background - wire-based

instrument to be attached to both upper and lower limbs that produce sound via the interactions between its attachments – Figure 3.12e;

- **Stochastico**: free improvisation - sax performer engaged with free improvised and experimental music with no music technology or instrument design expertise - percussive malleable instrument equipped with many different tools and materials for sound generation and exploration – Figure 3.12f.

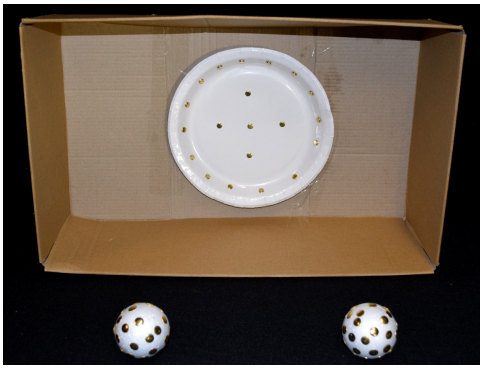


(a) AntennaLele (AL)

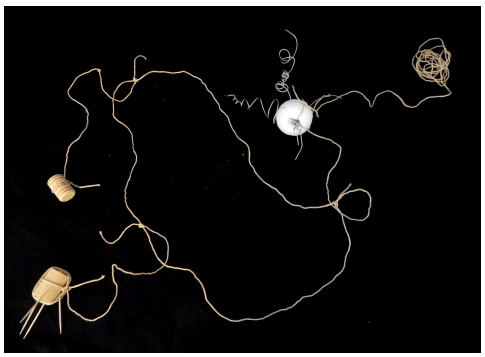


(b) Corpo-Suono (CS)

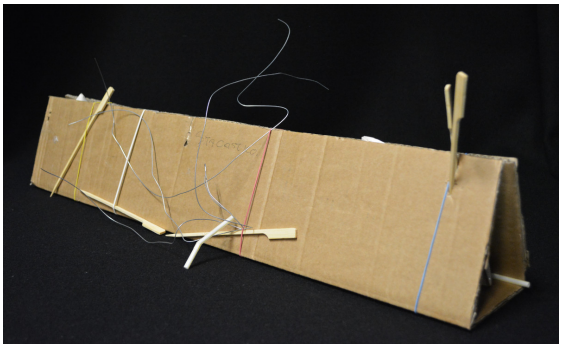
(c) Plucker (PL)



(d) NonStopSound (NS)



(e) SonicAlarm (SA)



(f) Stochastico (ST)

Figure 3.12: The fictional musical artefacts used in the survey.

3.3.2 *Survey design*

We ran an online survey targeting musicians and technologists with experience in musical interface design. We recruited the participants using academic mailing lists (NIME and SMC) and social networks. We aimed to see if respondents could discover musical values through the prototypes and link them to specific aesthetics and communities.

Survey participants reviewed an image of each fictional instrument and a short description of it provided by its creator [3]. For each artefact, the descriptions were assembled by quoting the creator's interview (artefact presentation) during the fictional design workshop (audio recordings manually transcribed). While selecting the quotes we aimed to compose descriptions that could briefly address the following topics: (i) prototype functioning and performative technique, (ii) envisioned musical purposes and aspirations, (iii) aesthetic and stylistic attitudes. The goal was therefore to present our survey participants with a brief but exhaustive overview of the various magical machines, thus providing sufficient context while avoiding biographical details – e.g. musical or instrumental backgrounds or involvement into specific communities. The survey asked the following open questions:

- *"What kind of musical style/genre do you think the musician plays? Why do you think so?"*
- *"What instrument(s) do you think this musician plays? Why?"*.

Each participant was presented with 3 of the 6 artefacts (balanced random order). After completing the survey, participants were required to provide information on their musical and technical backgrounds. This allowed us to get an understanding of their musical activities and training, style(s) of music they are engaged with, science, technology, engineering, and math (STEM) and design training and instrument design expertise.

3 See Appendix A for the complete collection of artefact descriptions and pictures provided to participants. Both questionnaires and results are available at http://instrumentslab.org/data/NIME2019SurveyValues.zip

3.3.3 *Data analysis*

The survey was open for one month and we were able to involve 22 participants: 5 female, 16 male and 1 no declared gender. The range of participants' age is 24-62 (mean 35). Almost all the participants declared to have experience in the design of musical instruments or interfaces (19) and to use music technologies (20). Almost half of them attended the NIME conference at least once (10).

We analysed the collected data following a thematic analysis methodology based on coding [105]. We adopted a data-driven (inductive) approach: looking for patterns, similarities and correlations while analysing the data [311]. We conducted five iterations of coding. From open coding to category formation each concept earned its way into the discussion by repeatedly being present in the data [99]. Based on the collected data we could also analyse in more detail respondents' musical and technical background:

- **Level of musical expertise**: amateur (12), professional (8), none (2);
- **Years of music practice**: between 5 and 10 (1), between 10 and 20 (11), more than 20 (8), none (2);
- **Musical training**: instrumental performance (12), computer music (including electroacousitc, sonic arts and live electronics - 3), composition (contemporary and traditional - 2), other (music production, instrument design and music theory - 3), none (2);
- **Main musical activity**: piano performance (4), guitar performance (4), instrument design (4), computer music (composition and performance - 4), brass performance (2), multi-instrument player (2), violin performance (1), composition (1);
- **Main genre**: classical (4), electroacoustic (3), EDM (3), experimental (3), jazz (2), improvisation (2), pop (1), rock (1), metal (1), folk (1), punk (1);

3.3.4 *Findings*

This section introduces the results of the survey data analysis. It was possible to identify several cues for the interpretation of the artefacts' origins, including physical features, body-instrument interactions, use of language and references to established music practices and tools. Tacit musical and cultural values were also recognised based on intuitive and holistic judgments.

Our results are then organised based on the following themes:

- Guess accuracy
- Motivations
  - Musical values and interests
  - Music notions and theories
  - Shared practices
  - Use of language
  - Gesture and body interactions
  - Artefact features and mentioned tools
- Guesses for each artefact

Guess accuracy

Participants were rather successful in guessing the genre/style of the artefacts' creators (see Figure 3.13): 44% of answers were correct, and a further 27% partly correct. 12% of answers were incorrect, 9% made no attempt, and 7% of answers were off-topic. On the other hand, participants were less successful while imaging the instrument played by the prototypes' authors: only 20% were correct, 21% partly correct, 40% were incorrect, 13% made no attempt, and 6% of answers were off-topic. Moreover, we did not find any correlation between the techno-musical background of the survey respondents and the accuracy of their guesses.

Responses we label as "partially correct" present some elements associated with the designer's background, without clearly identifying a community, genre/style or instrument that could be directly linked to the declared background of the musician that designed the fictional artefact. Responses of this sort might identify broad musical areas (e.g. tonal music), reference specific contexts (e.g. ensemble, labels and musicians) or point to some of the musical tools characteristic of specific genres/styles. Partially guessed comments also often refer to family of instrument (e.g. wind instrument) or identify an instrument/genre that has been declared as "secondary" by the creator of the artefact.

Motivations

Considering respondents' answers on *why* they guessed a particular background, we identified several themes. Sometimes participants did not provide any motivation for their guesses; during our analysis we created a *no motivation* category. These data were obtained based on the quantification of our codes. Due to the

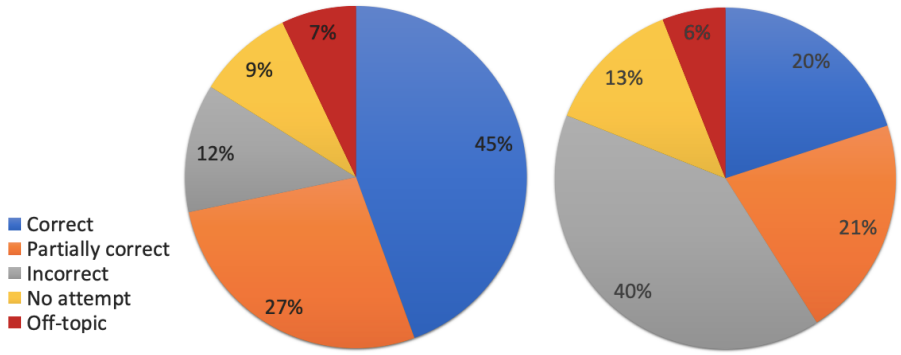


Figure 3.13: Guesses accuracy for musical backgrounds (left) and instruments (right).

presence of diverse themes within the same input, occasionally the same response has been coded multiple times (max input length = 109 words, average codes per input = 1.2).

MUSICAL VALUES AND INTERESTS While motivating their replies participants tended to introduce abstract concepts often related to musical values and interests. Most frequent comments of this kind include references to the ideas of *control*, *unpredictability* and *instrument agency*.

> **SA**[4] - *"Electroacoustic. The fact that the designed instrument does not allow full control would be hated by any other kind of musician"* – **ST** - *"Percussion instruments, because this chaotic logic of random sounds is closest to a percussionist set."*

Notions such as *manipulation* and *flexibility* were often mentioned.

> **ST** - *"It looks like the kind object you would devour with your hands, and you are looking at your hands with satisfaction as you manipulate and you hear the results of that tactile control."* – **AL** - *"Maybe improvised music. Try to merge a sax and a double bass sounds like a solo improviser who wants to expand his/her possibilities with an instrument that can be changed."*

The identification of compositional attitudes and interests towards experimentation were also common.

> **ST** - *"This object seems like something a composer would create, not necessarily a instrumentalist/musician. The temporary feeling of it lends it self to*

4 Abbreviations refer to artefact names; see Figure 3.12

degrade over time, providing more kinds of tones to the composer." – **BO** - *"I think the instrument would lend itself to experimental art music, or to a crossover fusion band of some sort. The timbres produced and the interesting (but complicated) performance techniques required would tend to make it less accepted by more mainstream ensembles and audiences."*

References to abstract and open-ended musical thinking were also emerging.

BO - *"Definitely something abstract and modern - for instance, not a classical player. Going to go with someone who perhaps sings or makes contemporary instruments..."* – **JM** - *"Due to the nature of the instrument this would be very indeterminate, so this notion should be fostered in the style the musician plays."*

MUSIC NOTIONS AND THEORIES Other recurrent themes emerged from our analysis are related to the presence of both music theory notions and spectromorphological conceptions of sound.

PL - *"The main parameters the musician seems to be interested in are pitch and volume. They mention the timbre/general sound of the instrument, but don't seem to interested in exploring and modifying its timbre or sound texture ... "* – **AL** - *"I think the person is a singer because they long for melodies AND harmonies of a complex nature, and the voice on its own is very simple."* – **NS** - *"it couldn't play any rhythmic style, probably only could to make effects with low attack sounds..."*

SHARED PRACTICES While discussing the fictional objects, participants tended to refer to musical practices typical of specific communities (e.g. orchestra). We also often found allusions to influential musicians, narratives and tools associated to particular artistic contexts.

CS - *"Classical. Conceptually, they are thinking of large ensemble performance and collective sound generation."* – **PL** - *"They also seem to be interested in polyphonic music, moving several voices to make chords, I interpret that kind of like Bach chorales..."* – **PL** - *"Clear Hugh Davies nerd here, probably really into kid 606 and the idea of katzenclaviers but would never build an actual one"* – **CS** - *"The form of the object reminds me of several indigenous percussion instruments..."* – **AL** - *"Maybe they are a sad church musician ... It sounds*

as if they are yearning for the structure of "melodies" and "harmonies" (all of which traditional church music provides) but in a completely other sound world ... (rather than singing the soprano line the whole time)."

USE OF LANGUAGE The use of language found in the description of the artefacts was often interpreted as a relevant cue. For instance, this emerged in regard to the metaphors used to express musical practices and intentions.

> **ST** - *"Definitely something abstract and modern. For instance, not a classical player ... Mainly based on comments such as 'I usually do ... shapes of sound' suggests they are used to thinking about novel instruments and the language is more conceptual and not precise ... (And for instance classical musicians, tend not to always be that creative.)"* – **AM** - *"Experimental contemporary music. Mentioned 'shapes of sound'. I think the musician is an improviser."*

Alternatively, specific terms were identified as markers. Thus interpreted as powerful hookups towards specific musical community.

> **NS** - *"Synths, and production - if you are talking 'production' you are talking recording and if you are choosing your sound in production, typically not live instruments so yup, sticking with EDM."*

GESTURE AND BODY INTERACTIONS Participants often considered the gesture and body interactions implied in the artefacts or stated by their authors.

> **PL** - *"Guitar: 'the way you stroke a certain string can alter the pitch depending on how much pressure you use on it.' A subtly of guitar playing, not a major interaction."* – **PL** - *"Clarinet, but with strong background in piano. They have a sense of the importance of touch and pressure..."* – **PL** - *"Guitar and bass, because of the strumming and plucking gestures the instrument induces, keyboard synthesizers, because of the idea to press something to produce the sound..."*

ARTEFACT FEATURES AND MENTIONED TOOLS Artefact features such as shape, functioning and accessories were often used to decode the prototypes, generally by comparing them with existing musical instruments and tools.

> **CS** - *"Wind of some sort ... they are looking to mechanise wind instrument tone production."* – **ST** - *"The percussive aspects of the object make me think*

maybe a drummer has made this. I do not think a wind or read player (any mouth instrument) made this." – **ST** - *"Possibly a guitarist. Applying strings to a oblong body is guitar-like."*

Finally, the musical tools mentioned in the description of the instruments were often used to identify the genres and instruments associated to the background of the object's inventor.

NS - *"I think the musician likes or makes electronic music. A synth and randomness has been mentioned. Could also play some other instrument."*

Overall, the most frequent themes used to discuss genre/style were abstract values and musical notions followed by situated/embodied practices and tools. Less referenced are those themes linked to the artefacts' interactions and physical features. On the other hand, the instrument guesses were often directly motivated by the prototype's aspect, configuration and material affordances. Musical values and notions where less frequently introduced and references to practices, communities and language rarely appeared. Figure 3.14 shows the recurrence of the motivation' themes provided by participants to justify their guesses.

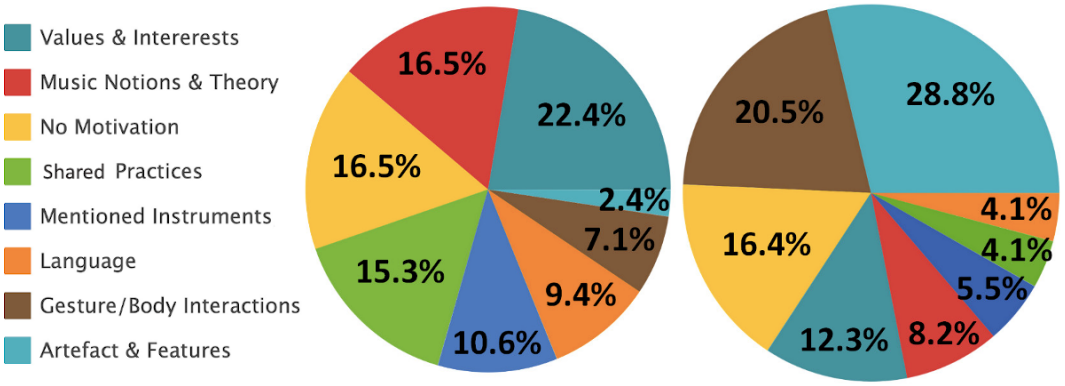


Figure 3.14: Code frequency for genre/style (right) and instrument (left) guesses

Guesses for each artefact

Figures 3.15 and 3.16 show the percentage of guesses for the targeted genre/style and instrument, grouped into categories of genre and instrument. Participants mainly considered the AntennaLele to be created by a jazz musician. Specific music notions (e.g. melody, harmony and chord) and values (i.e. variety and flexibility) were often associated to this genre.

AL - *"Jazz, Electronic, they want a flexible moldable instrument"*.

For the instrument guess, the musician has been often imagined as a double bass player due to the similarities with the artefact form.

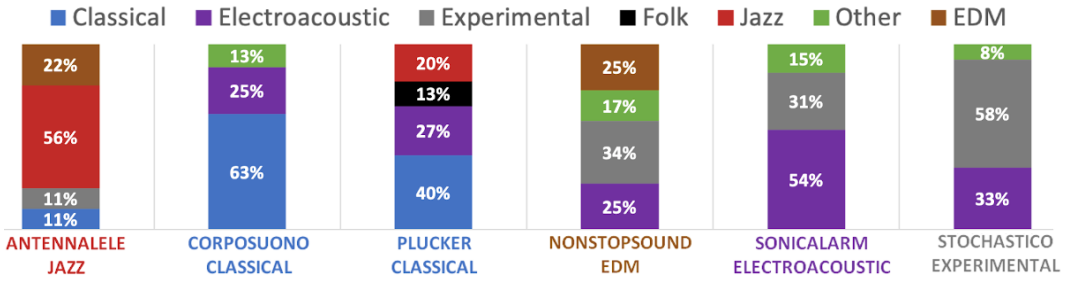


Figure 3.15: Percentages of the participants' genre/style guesses for each artefacts.

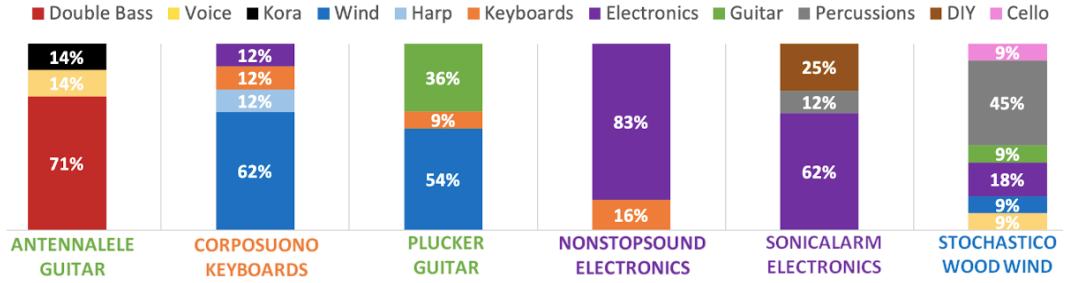


Figure 3.16: Percentages of the participants' instrument guesses for each artefacts.

Corposuono has been mainly interpreted as created by a classical musician. The reasons given were mostly music theory notions and practices linked to the classical culture (e.g. large ensemble and chords). Many participants suggested that the musician should be a wind instrument player due to artefact's structure and functioning.

CS - *"A wind instrument. Because of the configuration of the prototype"*.

The **Plucker** was often linked to the classical genre, mainly in reference to the traditional music notions expressed by the creator while presenting the artefact (e.g. pitches and notes).

PL - *"Classical/Jazz, because of the importance of pitch and the organ reference"*.

The instruments mentioned in the prototype description (i.e. organ and french horn) were often associated to the classical domain and often participants imagined the designer to be a wind instrument player. However, various participants

identified the correct instrument based on the gestures and interactions mentioned by the musician.

NonStopSound has been associated to diverse genres. Experimental and electroacoustic due to the indeterminacy linked to the sound production technique, and EDM due to the language used to describe the object. On the other hand, most participants recognised the musician's instrumental background.

> **NS** - *"Maybe modular synth or a high level dedicated audio programming environment ... The way she describes playing seems indeterminate so perhaps has not received a formal musical training"*.

Due to the originality of the artefact configuration and the discourse on instrumental agencies and chaotic behaviours, respondents associated **SonicAlarm** to electroacoustic and experimental genres.

> **SA** - *"I imagine some kind of experimental/noise electronic music, because of the randomness he's seeking. Also because it would mix music with some performance that would involve human body through walking or throwing things"*.

For the same reasons the artefact has been often interpreted as invented by a performer of electronic devices (e.g. synth, laptop or DIY instruments).

Finally, **Stochastico** has been often related to experimental contexts (including free improvisation, contemporary and alternative genres). The motivations provided often referred to the precarious nature of the instrument and the particular language used to describe the object.

> **ST** *"Discussion of 'sculpting' sound is suggestive of electro-acoustic music styles, rather than of mainstream diatonic concerns"*.

Furthermore, many participants imagined the musician to be a percussionist due to the structure and functioning of the artefact.

3.3.5 *Survey discussion*

These findings suggest the presence of various affinities between the themes and designer backgrounds. For instance, instrumental agency, unpredictability and exploration were often considered as electronic and experimental concerns. The same applies to interests in timbre manipulation and abstract musical thinking. On the

other hand, values such as control and flexibility and references to traditional music theory were often related to classical and jazz domains.

Interestingly, these tendencies seem to be mainly related to cultural and aesthetic attitudes rather than the designer's experience with music technology. Our participants often associated the same set of musical values with designs produced by musicians with very different instrumental skills. For instance, artefacts such as SonicAlarm (electroacoustic composer with an engineering background), NonStopSound (alternative EDM producer with a background in instrument design) and Stochastico (sax player active as free improviser with no music technology expertise) were often associated to the same set of values and interests (e.g. unpredictability and timbre exploration). If the degree of accuracy for the discovery of aesthetic interests and cultural influences was quite accurate, the identification of the instrument played by the inventors was instead less precise. Various participants based their judgement scrutinising the artefacts' physical features, thus looking for direct similarity and analogies with already existing instruments. This association was often unsuccessful as the fictional objects are generally very different from the instruments played by their creators.

Another point of discussion relates to the overall ability of the survey respondents to discover the multiplicity of cultural sources and musical practices in the designer's background. One example of this sensitivity is provided by NonStopSound. By looking at the general picture, the stylistic musical influences identified across all respondents somehow properly summarises the profile of the artefact's creator (i.e. active in the context of experimental electro-pop who performs using custom designed instruments and synths).

While considering the particular backgrounds of our participants and responses provided, we did not find any distinctive trend (e.g. in regard to specific musical backgrounds or technical expertise). However, by analysing the information collected, it is possible to deduce that the majority of our participants are knowledgeable or expert music technologist active in specific communities of practices for a considerable period of time (i.e. for 10 years or more). The involvement into particular communities of practice implies "ways of learning - of both absorbing and being absorbed in - the culture of practice" [218, p. 169]. We suggest that this research provided the possibility to engage with this type of knowledge: context-dependent values emerging from situated practices and experiences – see Section 2.3.2. This is supported by various participants' comments which might

be interpreted as related to empathetic feelings and unconscious dynamics rather than rational and deductive inferences.

> **PL** - *"This person seems like a classical musician ... There is something familiar to me about how this person seems to think of the sounds 'altering with your hands', 'altering the pitch depending on pressure' ... I sense that I speak a similar language to this person, musically, and my own background is strongly classical. So I feel this is a classical family member."*

3.4 DISCUSSION

The reflections here presented do not propose an explanatory model of any particular individual's values based on their musical or technical background, and I acknowledge that the sample musicians involved in the studies is likely not representative of musical practice as a whole. As author, I also cannot claim cultural neutrality in my analysis, though I present in previous sections a thematic analysis process that seeks to minimise bias – see Section 3.2.4. As researcher, I self-identify with electronic and improv communities, which may colour some of my reflections. Acknowledging these sources of variation, I nonetheless want to highlight the importance of seeking a diversity of sources of influence for every participant and acknowledging the breadth of priorities within each community. With this in mind, in what follows I present a set of concluding reflections which aim to summarise some of the main lessons learned out of the two studies.

3.4.1 *Dealing with a polyphony of sources*

The two studies presented in this chapter illustrate how individual participants' values derive from a variety of sources. Participants' representations seem to correlate strongly with their communities of practice. Probably, the clearest expression of such outcome is the dichotomy between communication-oriented and material-oriented values that emerged out of the design fiction workshop. The former, often found in classical players, imply the instrument as a transparent mediator and they have been conveyed, for example, through artefacts which were abstract representations of communication amongst musicians. The latter interpret musical artefacts as explorable devices which might have their own autonomy – a view mainly shared by improv and electronic practitioners. Material-oriented values

were frequently revealed through literally functional sonic objects and discourses on material agency and exploration.

Nevertheless, other sources of influence emerged as well, including embodied knowledge from instrumental training. For example, guitar players tended to make fictional instruments resembling the physical features and body movements typical of guitar-like instruments. A further source of influence, irrespective of musical community, was technology training. We found that despite the prompt to build instruments "as if by magic", technologically-trained participants were affected by what they believed to be possible with current (mostly digital) technology. These findings resonate with embodied cognition theories arguing that tools reshape our perception, altering how we act, thus changing how we think about things [212].

Similarly, in the second study participants were able to identify a great assortment of values inscribed into the artefacts. Notably, these embedded notions were rather successfully associated to the musical contexts of the instruments' makers. Such clues highlight the effects that communities have on the conception and design of novel musical tools. In particular, we could appreciate a clustering of shared values linked to modern and contemporary music *versus* more aesthablished genres. For instance, open-endedness and indeterminacy were often related to experimental settings whereas concepts coming from traditional music theory (e.g. notes, chords, and polyphony) were generally associated to classical and jazz contexts.

However, the study provided us with the opportunity to discover additional shared factors steering the interpretation of the artefacts. For instance, body gestures and physical interactions have been often exploited to guess musical backgrounds. In particular, minor and subtle details linked to the sense of touch helped various participants to identify the instruments played by musicians. The use of language was another important factor which facilitated music technologists to speculate on the origins of the fictional artefacts. Interestingly, in both studies, language was sometime a source of discrepancy, with terms taking on very different meanings. For instance, the word "expressive" could refer to the ability to communicate artistic intentions, it could be used to indicate high control bandwidth, or might evoke the possibility of producing many different timbres with an instrument. The term "gesture" instead might indicate abstract musical metaphors or denote physical movements.

3.4.2 *Discovering values through fictional designs*

This research exploited design fiction to access contextual interpretations of skilled individuals engaged with specific communities of musical practices. We were able to discover a broad range of concerns and significances inscribed into imaginary and not-yet existing music technologies. Within this spectrum we identified three perspectives (instrument-, material- and communication-oriented) which combine some of the frequent and shared attitudes we found in the work of participants. Whether or not our analysis produced sensible and verifiable insights, we could clearly see how this multiplicity of values and mindsets have been also detected by other musicians, namely experienced music technology practitioners. Indeed, despite the good degree of accuracy in guessing musical backgrounds, our research showed how musicians can *perceive* rather nuanced and distinctive cues embedded into the artefacts and vehiculated through the discourses around them.

The investigations provided us with the opportunity to engage with acquired instrumental conceptions and deep musical understandings. In particular, the second study let us better grasp how such musical values are often interpreted based on feelings and sensations rather than rational and deductive mechanisms. Participants often resonated with subtle instrumental features – whether material or conceptual – often based on tacit knowledge absorbed through experience and participation in communities of practice. As these know-hows are profoundly internalised, to the point of becoming assumed for granted, a good amount of effort is generally required to reveal them – i.e. making them available for critical reflection. Moreover, we would argue that this is particularly true when aiming to explore our own values, or confronting those of the contexts and communities to which we mainly relate to.

The findings presented in this chapter also point towards two compelling observations. First, our studies suggest that some of the instruments' interpretations and conceptions identified are detached from technological and instrumental practices. For instance, during the As If By Magic workshop, musicians practicing different instruments and active in more contemporary and vanguard contexts (e.g. free improvisation and electro-acoustic) often manifested similar values – amongst others, a strong interest in the exploration of materials. This element was further confirmed in the second study, as survey respondents were more successful in guessing the style/genre of instruments makers rather than the instruments they play. Moreover, also in the survey we could appreciate the emergence of "cross-

instrumental" values which have been associated to either more contemporary practices (e.g. experimental/noise electronic) or long-standing musical traditions (e.g. jazz and classic).

Second, the ability of music technologists to discover cultural affiliations and musical backgrounds might reveal the predisposition of the members of this community to perceive a broad variety of musical matters typical of different contexts. In other words, music technologists seem to be rather good at discovering musical values, at least those inscribed into musical artefacts. Due its strong multidisciplinary character, various research pointed at the many disciplinary frictions emerged within the NIME context throughout the years – e.g. [170]. Nevertheless, just because of the hybrid nature that qualifies music technology practices the researchers active in this domain might develop a set of expertise which provide them with good conceptual (and material) tools for the interpretation of divergent musical mindsets and instrumental attitudes; a condition that places music technologists in valuable spot for the sighting of notions and practices coming from very different musical territories.

3.5 CHAPTER CONCLUSIONS

This chapter has presented two studies concerned with the discovery of musical values inscribed into not-yet existing musical instruments. The research allowed us to directly engage with a broad set of perspectives and attitudes towards the interpretation of musical interactions which were largely shared amongst musicians active in the same musical contexts.

We exploited design fiction to access those contextual visions inspired by the Magic Machine workshop introduced by Kristina Andersen [14]. Andersen's methodology proved to be an effective and powerful device to access cultural assumptions and subjective experiences. We then expanded Andersen's approach based on our own research concerns. The analysis of the data collected and the speculative design enquiry involving music technologists are therefore further steps introduced by us in order to shed some light on the transferring of cultural values into fictional music technology artefacts.

A technology-driven design exercise might have defined a specific problem space according to the affordances of that technology, privileging "how" of achieving particular outcomes over the questions of "why" that showed the greatest difference between musical communities. Instead, the question of "why" can be

examined both through the artefacts themselves and the explanations the participants give about their reason for existence.

Following Andersen's proposal that "the object [fictional artefact] is not important in itself, but rather, it forms the container through which a vision or idea might be relayed" [12, p. 98]. We then suggest that design fiction activities, such as the methodology outlined in this chapter, can be used not only to generate new ideas (following Andersen) but also as an analytical tool to reveal sources of influence and value systems which could be explicitly considered before moving to the next phase of designing technological systems.

Based on the work of our participants, we presented three main approaches for the understanding of both musical artefacts and the instrument-performer relations. These point towards agreement with previous research, especially Mudd and Bijsterveld [274, 43]. In addition, our results clearly show that the design of a technology therefore entails the inscription of shared values situated in specific communities, contexts and cultures. The musical notions inscribed into a design are then crucial for its interpretation and use [4].

Overall, the work here introduced can be seen as an evidence-gathering step as part of a "culturally-aware" approach for the design of musical interactive systems. An approach that aims to clarify the influence of specific musical backgrounds and cultural environments, thus framing the context-based point of departure and identifying mindsets, attitudes and objectives according to specific set of values and interests.

4

ON DIGITAL MUSIC TOOLS AND MATERIALS

This chapter incorporates significant material from 'Embrace the Weirdness: Negotiating Values Inscribed into Music Technology' by Lepri and McPherson, currently under review, to be published in the Computer Music Journal [226] and 'Beholden to Our Tools: Negotiating with Technology while Sketching Digital Instruments' by McPherson and Lepri, originally published in the proceedings of the International Conference on New Interfaces for Musical Expression, NIME 2020 [258].

This chapter explores the ways specific hardware and software technologies influence the design of musical instruments. It presents the outcomes of a compositional game in which music technologists created simple DMIs using common sensors and the Pure Data programming language (Pd). I report on the clustering of stylistic approaches and design patterns identified while reviewing the instruments, considering these findings in light of both makers' techno-musical backgrounds and the musical interactions promoted by the tools and materials provided. The final discussion examines digital instrument design as a situated negotiation between designer and tools, wherein musicians often react to suggestions offered by technology based on their previous experience.

4.1 BACKGROUND

The varied and compelling research findings presented in Chapter 3 gave us the opportunity to access musical values and knowledge shared within particular socio-musical contexts. The playful and non-functional qualities of our work soon led us to wonder how design outcomes would change if we ran a playful and open-ended activity, similar to the workshop presented in the prior chapter, but with a focus on functional technology. This chapter poses questions on the role that *digital tools and materials* play in the making of a DMI, aiming to provide an antithesis to the speculative approach previously introduced. The intention is to offer a contrasting account where music technologists are invited to quickly make sonic interactions using actual audio interface components. We then examine in

detail the influence of a small selection of tools and materials within the context of a creative interaction design game. The research then proposes to observe how diverse practitioners' musical ideas and approaches are transduced and materialised while manipulating the same digital tools and materials.

Digital music tools are often depicted as pliable vehicles which provide access to audio manipulation at various levels, from primitive operations to predefined musical abstractions, allowing musicians to create a great variety of sonic structures. Most contemporary music programming languages are indeed Turing complete,[1] meaning that they are theoretically capable of representing any possible sonic outcome. In principle such openness of expression ought to lead to rapidly diversifying musical ideas. However, new digital musical interfaces and instruments often (dis)play similar aesthetics and interactions [270].

Teachers of musical interaction design will be familiar with the tendency of beginning students to create theremin-like instruments [191] or to use touch sensor boards to arrange arbitrary objects into rudimentary keyboards [115]. Attendees of NIME concerts will encounter a recognisable prevailing (though by no means universal) aesthetic, often including drones, textured noise or manipulated samples. If technology opens up the possibility to produce any imaginable sonic interaction, what explains this clustering? The work reported in this chapter asks whether this clustering is due to cultural dynamics (e.g. pedagogical and aesthetic habits [249]) or to the standardisation and spread of specific tools within interactive art and music technology communities [343].

In Section 2.2 we discussed some of the socio-cultural implications of technology ideation and development. Based on this framework, the research presented in this chapter relates to a particular set of investigations examining the non-neutrality of technology within the domain musical interaction. A primary source of reference is the ethnographic investigation by Born and Snape on the Max audio programming language which, along with programming practices, also considers broader socio-institutional mediation linked to the development and use of the software [67]. McPherson and Tahıroğlu instead, discuss the "idiomatic patterns" promoted by specific digital music tools considering the views of several developers of major music programming languages and DMI creators [259].

Thor Magnusson focuses on understanding "how emerging digital music technologies trace their concepts, design and functionality to practices that precede

1 Turing completeness is a construct of computability theory which means that a language can be used to simulate any Turing machine, or more informally, that it can be used to represent the same set of possible computations as every other Turing-complete language.

our culture epoch" [244, p. 23]. Magnusson then considers the musical instrument as an "epistemic tool" that embodies actual musical knowledge and therefore offers specific "affordances, expressive scope, and theoretical potential" [p. 72]. On a more political level, Tomás reflects on the prevailing tendencies for musical creation with digital interfaces by focusing on their commodification [346]. More recently, Morreale et al. [271] examine instruments as cultural artefacts which reproduce political discourses, identifying a need for researchers to engage with socio-cultural and ethical topics beyond academic contexts.

This investigation attempts to unpack some of the modalities through which specific music technologies influence the design of DMIs. In particular, in line with the research concerns posed by Born and Snape [67], this chapter examines the *aesthetic situatedness* of digital music tools. In order to explore the aesthetic influence of specific music technologies, we created a musical game based on the composition of simple DMIs. The activity is conceived as a playful hands-on exercise in which music technology practitioners are invited to design sonic interactions using the Pd language and a basic hardware interface. We refer to the etymology of the term "compose" to frame our activity (*com* - "with" or "together" + *ponere* - "put", "place" or "arrange"). We then envisage musical artefacts as multifaceted assemblages resulting from the aggregation of sonic, temporal, corporeal, technological and social leverages [62]. Based on this mindset, we investigate the design of new DMIs drawing from a RtD perspective [140].

4.1.1 *Research questions*

The research presented in this chapter addresses the following research question:

How do digital music tools influence the design of novel musical interfaces?

In particular I ask:

- How can we identify the cultural load carried by a particular music tool?
- How do the values embedded into musical tools condition new musical interactions?
- How do musicians react to the suggestions offered by technology?

This section introduces a study in which music technologists were asked to sketch simple musical interfaces with common electronic sensors and the Pd programming language [302]. The instruments were developed as part of a musical game designed to engage participants in a brief and creative prototyping session.

4.2.1 *Instrument making*

Our compositional exercise requires two participants at a time. For each game, two instruments are designed and participants work on both instruments. Participants are provided with a breadboard containing three sensors commonly used in DMI design: a pushbutton, a potentiometer (with knob attached) and a force sensing resistor (FSR). The sensors are pre-wired to a Bela board [260], using a digital input for the button and (16-bit) analog inputs for the other two sensors. The activity workflow involves creating Pd patches on a computer and uploading them to the Bela board where they could be tested. Two workstations are prepared, one for each participant: a computer, a Bela with three connected sensors and a pair of headphones (see Figure 4.1 and Figure 4.2).

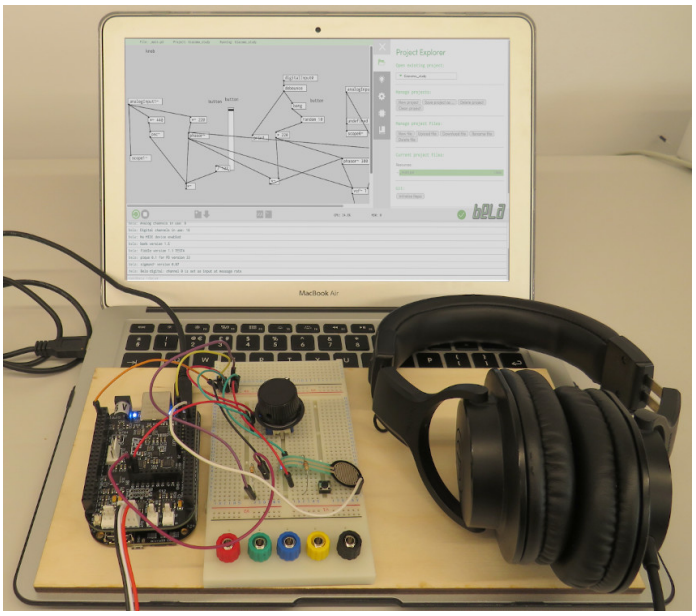


Figure 4.1: Each participant independently sketches simple instruments using common sensors, Bela and Pd.

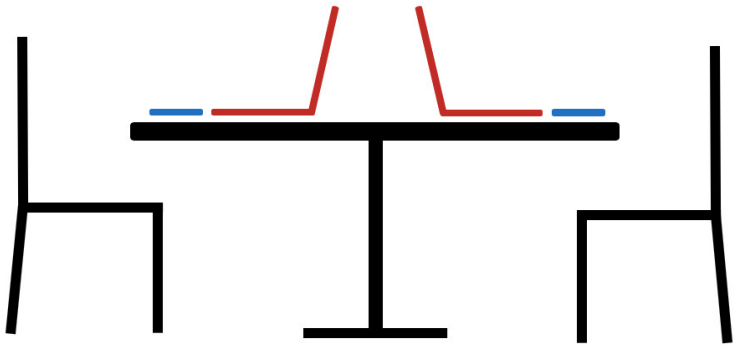


Figure 4.2: Setup of the compositional game, one station per participant, facing one another.

The making of the instruments is organised in several short steps. First, the facilitator invites both participants to design a simple audio algorithm to be controlled by one of the available sensors (chosen at random). Participants then move to the opposite side of the table, taking the place of the other person. They are then are invited to start a new Pd project with a new sound algorithm to be controlled by one of the two remaining sensors available at the workstation (chosen at random). Afterwards, participants swap places again, and the facilitator asks participants to start a new Pd project and work with the remaining sensor. Finally participants are invited to make a new Pd patch gathering together the three algorithms saved on their current workstation. During this last step, participants are requested to review the overall instrument, modifying and improving it according to either aesthetic or technical concerns. By the end of the making each participant is able to play an instrument featuring the three sensors.

We ran two different versions of the study, each following the same structure but with a difference in the first step. In the second version of the game, participants randomly selected two sensors to start with. Four pairs played the first version of the game (one sensor at a time) and three pairs played the second version (starting with two sensors).

To emphasise the playful nature of our study, the activity is introduced as a collaborative game, based on our previous work (see Chapter 3 and Chapter 5) where playful group activities proved to be particularly suited to promote creative design practices. Furthermore, participants have a limited amount of time to compose each algorithm: from 10 to 15 minutes for each step. We borrowed this approach from the work of Kristina Andersen on the Magic Machine workshops, in which participants are engaged in open-ended and short activities which encourage them to "think with the hand" [14]. Our intention was to present par-

ticipants with fast paced and easily achievable tasks, encouraging making without overthinking, thus promoting spontaneous and intuitive material assemblages.

Although our activity focused on Pd and the three specific sensors, we also ran one session of the game involving two expert users of the SuperCollider language [255]. In later sections of this chapter, we will occasionally comment on the work of these musicians, mainly to support specific reflections on the instruments designed with Pd. The choice of having two music technologists working with SuperCollider relates to the intention of conducting a preliminary exploration of the analogies and differences between different tools and related practices – i.e. comparing meaningfully different cases [77].

4.2.2 *Instrument presentation*

Once the making of the instruments is completed, participants are invited to present their work to the facilitator and perform a short demonstration. Making is here used as a means for speculation and reflection: participants are invited to unpack their actions, disclose priorities and examine design processes and outcomes [322]. Our intention was to discover makers' values, motivations and felt experiences through the composed musical artefacts.

While illustrating the instruments participants are encouraged to elaborate and expand on their work. The facilitator asks open-ended questions in the form of a semi-structured interview, often inviting participants to elaborate on the instruments' functionalities and sonic properties (e.g. what were your musical intentions? How did the making process evolve? What are the relationships between sensors, algorithm and sound? How should the instrument be played?). As participants are also invited to comment on the work of their teammates, the interview often evolved into small group discussions. We found that the emergence of different interpretations and viewpoints often turned out to be a stimulus for participants to further consider their work.

This concluding stage was audio recorded, manually transcribed, coded and analysed based on an inductive approach [105]: looking for patterns, similarities and diverse degrees of agreement across the participants' reflections [311]. The results of our analysis were collected in a codebook which was systematically updated and refined. The various codes were organised by categories: groups of codes that shared specific elements and features. We conducted five iterations of coding, and only once the codebook was established did hypotheses or theories

emerge. The method adopted (from open coding to category formation) forced us to critically look at data through different lenses [178] and each concept earned its way into the discussion by repeatedly being present in the data [105].

4.2.3 *Participants background*

ID	Music activities	Music technology background	Pd level
P1	Electronic music composition & performance, music interfaces design & research	Electronic music composition, music technology	High
P2	DMI design & research, audio programming, live band performance	Audio engineering, sound & music computing	High
P3	Audio engineering, audio-visual production, sound design	Audio engineering & music production	Low
P4	Sound design, audio programming, modular synth performance	Sound & music computing	Low
P5	Sound design, collaborative music applications research, live band performance	Sound & music computing	High
P6	Music composition, sound design, music technology teaching	Music technology & composition	Medium
P7	Electronic music composition & performance, DMI design & research	Music & creative practice, film production	Medium
P8	Music performance research, choral and solo singing, live band performance	Sound & music computing	Low
P9	Electronic music composition, live coding, computational creativity research	Music technology, mathematics	Medium
P10	Accessible DMI design & research, live band performance	Music technology, design, electronic engineering	Medium
P11	Music production, sound design, audio engineering research	Electronic engineering, digital signal processing	High
P12	Electronic music composition & performance, live coding, DMI design & research	Music technology, multimedia, design	High
P13	Electronic music composition, modular synth & live band performance	Mathematics, computer science, music technology	High
P14	Electronic music composition, sound design, live band performance	Computer science, interactive media	Medium

Table 4.1: Summary of participants' background and musical activity.

Our research involved 14 music technologists (7 pairs) - 10 male, 4 female, aged 23-37. We recruited our participants mainly through an academic institution: Queen Mary University of London (Centre for Digital Music and Media and Arts Technology Centre). After recruitment, information on each musician was collected through an online survey - see Table 4.1. All participants reported to have studied music whether through self-taught, formal or informal training. All participants play at least one instrument (including 7 guitar/bass, 6 electronics/laptop, 1 vocalist). All participants self-identified as music practitioners, where 11 participants have been active musicians for more than 15 years. 8 participants identified as professional musicians and 6 as amateur musicians. At the time, the majority of our participants (13 out of 14) were working as doctoral or postdoctoral researchers in different fields - e.g. SMC, DMI design / NIME, cognitive science and HCI.

12 participants reported having at least basic training in electronics, programming and mathematics. Within this group, most (9) encountered these subjects through music technology programmes (undergraduate and master's level) such as audio engineering or electronic music composition. 6 participants received formal training in the fields of humanities, and 4 of them hold a graduate or post-

graduate degree in music performance or composition. The musical activities of our participants are quite diverse. Most of them are active in multiple musical contexts (e.g. audio engineering and live band performance), dealing with different sets of practices and genres. We were able to gather information on the aesthetic and stylistic preferences of our participants (e.g. favourite genres and influential musicians or ensembles). Again, they showed interest in a large and diverse set of musical styles; some of the most cited genres are experimental electronic, techno, ambient, experimental pop, rock, funk and jazz.

We were also able to get a sense of participants' level of expertise with computer music languages, and more generally, on their previous experience in sound design. All participants worked with Pd in the past, some on a regular basis and others for short-term projects (e.g. university assignment). 8 participants had formal training in Pd, and 7 participants had experience with other music programming languages such as Max, ChucK, Csound, SuperCollider or TidalCycles. Participants self-rated their level of Pd proficiency, and based on this evaluation and on our own data analysis (i.e. patches and interview analysis) we categorised three groups of Pd expertise: low, medium and high.

4.3 FINDINGS

The findings introduced in this section are organised as follows: first I describe participants' engagement with tools (i.e. Pd patching and use of sensors). I then integrate these observations with a summary of musical and technical concerns expressed by participants while reflecting on their work. Finally I examine the sonic interactions and aesthetic qualities of the various instruments. Moreover, findings are often discussed in reference to participants' musical and technical backgrounds.

The themes identified in our analysis are listed below and then described.

- Patching and workflow
- Sensor thinking
- Original and unconventional making
- Aesthetic considerations

4.3.1 *Patching and workflow*

It is important to emphasise that our research is not a study of a mapping toolkit which permits only a limited set of predefined relationships between sensors and sound. Rather, in principle nearly any relationship could have been expressed in Pd using the sensors provided. Nevertheless, we found that most control relationships fell into just a few categories of sensors manipulating fundamental sonic parameters (e.g. frequency, amplitude), usually in a linear, time-invariant, 1-to-1 manner. Indeed, out of 50 patches, only three Pd objects were responsible for the original sound in every case: `osc~` (sine wave oscillator); `phasor~` (simple 0-1 sawtooth oscillator with no antialiasing); and `noise~` (white noise). Surprisingly, the findings reported in this section are common to all participants regardless of their musical backgrounds or level of Pd expertise.

It is equally important what we did not see in the final instruments. None of the instruments involve the quantisation of pitch to a musical scale, rhythmic patterns (other than constant regular interval metronomes) or sample playback or looping mechanisms. Similarly, we could not find step sequencers or other pattern sequencing of control parameters other than two instruments using the button to step through fixed frequency values (e.g. harmonics of a given fundamental). Only one participant made use of *if conditioning* statements and none of the instruments include logic resembling *for/while* loops. Dynamic instantiation of synthesis processes, for example increasing or decreasing the number of oscillators on the fly, is also not present in the patches reviewed. By convention, the control data from each sensor is normalised between 0 and 1 at the input from Bela. With the exception of some amplitude controls, almost all instruments rescaled this range in some way. Linear relationships between sensor and sound parameter were by far the most common even though both amplitude and frequency are typically perceived on logarithmic scales; only one participant explicitly commented on the implementation of a logarithmic input scaling using the `log~` object, whereas another participant rescaled the FSR input with the the `mtof` MIDI-to-frequency object to control the cut-off frequency of a filter.

Participants made use of only a small number of Pd functions and control strategies. During the final group discussions, 5 participants highlighted the structural similarities between their designed patches. In the case of P11 (a researcher in machine learning and music working in the private sector) and P12 (a musician and

technologist with a experience in NIME research and live-coding performance), these comments relate to both patching techniques and musical outputs.

> *P12: "that's funny that we kind of did the same thing!" Facilitator: "in terms of sonic output and aesthetics?" P12: "yeah like beating saw waves.." P11: "we are both using step 1 to modulate what each other did in step 2.. like I modulated what P12 did and P12 modulated what I did.."*

Similarly, P5 and P6 agreed on the fact they implemented the same Pd algorithm with the FSR sensor.

> *P6: "you know I think you did a pretty similar thing with the FSR as I did right? It's like a sawtooth that's just going up in pitch by an octave and the volume increases at the same time".*

In line with the ethnography of Born and Snape [67], we found that Pd patching often manifested as an "open-ended and unpremeditated compositional process" in which short "bursts of coding" are hesitantly combined together without necessarily knowing what the result would be. Indeed, half of participants acknowledged that while patching they were not always fully in control of their work. This intuitive, exploratory and permissive coding approach often led to the emergence of unexpected results which are embraced even if resulting from unintentional or misinterpreted patching. P3 and P4 (PhD students in SMC and audio engineering with low Pd experience) provide a good example.

> *P4: "I've just routed the phasor to really random places.. yeah, I just sent to there to see what happened which is also being controlled by this.. this knob is just controlling.. maybe it's just controlling the frequency of one of the phasers?"– P3: "this one [knob] I have no idea what it is, but it's cool! It's randomly generated... it's like multiple oscillators".*

Another prominent workflow relates to combining existing patches, copying and pasting snippets of code. Figure 4.3 shows an example of such a procedure, where P11 duplicated the same combination of objects multiple times.

> *P11: "I also think at some point I was not 100% in control of what I was patching... because when I was duplicating and inverting everything and then duplicating again and inverting everything... kind of lost track of what really is doing".*

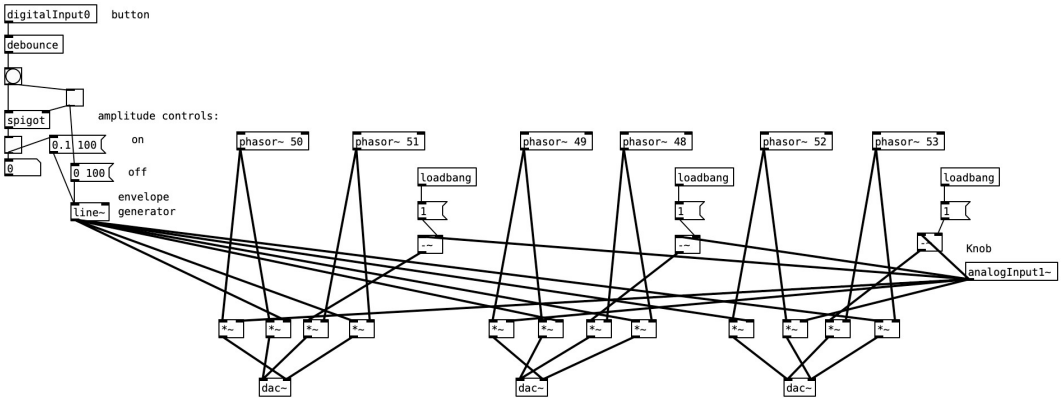


Figure 4.3: An example of copy/paste routine where the same combination of objects is reiterated multiple times. Visual layout of the patches is participants' original wherever possible, with minor adjustments for space.

We especially noticed this procedure in the final step of our game, as participants were required to gather the code from previous steps into a single patch. Although we were not surprised to see an increase of copy/paste routines in the final step, we observed that all participants rapidly combined the various patches with almost no adjustments. 10 participants mentioned how they combined existing Pd patches simply merging their outputs. Typically, multiple oscillators were either summed in basic additive synthesis or multiplied together in a form of amplitude modulation.

By comparison, the two musicians that played the game using SuperCollider lamented a lack of time for the final step as they had to address a number of technical issues to be able to gather and run the previous code (e.g. renaming of variables and modification of synth methods). Despite being expert users, both musicians spent most of the final session trying to adapt their work in order to be able to simultaneously play all three sensors. As if SuperCollider would "fight against" a certain kind of assemblage procedure, these two participants had to focus in finding suitable workarounds that could allow them to perform and listen to the complete instruments.

These reflections resonate with the observations of Born and Snape [67] on how many Max practitioners use "ready-assembled groups of objects so as to accelerate patching and make it as musically seamless an experience as possible". Born and Snape highlight how such practices, shared within the Max culture of copy-pasting code and reuse of abstractions, are partially a consequence of users' appropriation (or *détournement*) of Cycling '74 help files and documentation. It is possible to argue that such culture of use is common to programming practices and tools

that extend far beyond music programming languages [159]. However, our point is that specific music technologies, as Max or Pd, clearly facilitate a copy/paste approach by default, whereas with other tools this might be more challenging and laborious.

4.3.2 *Sensor thinking*

The constraints provided by sensors were also often mentioned as a driving factors by participants.

> *P10: "the main thing that was influencing what I wanted to do in each stage was the sensor that I was using".*

We were intrigued by a comment from P7, a professional musician active in the context of experimental electro-pop pursuing a PhD on musical interface design. P7 noticed how, having two sensors to start with, she directly went for the combination of the two, instead of designing two different sounds to be controlled separately by each sensor.

> *"yeah, it's like 'you are a button and a knob, what can they do? obviously they'll do something better if I combine them .. like 'oh I'll make one affect the other!' .. but really we didn't have to do it that way!".*

Indeed, all participants that played the second version of the game – i.e. having two sensors to compose in the first step – took the same approach: having two sensors to start with strongly encouraged their combination.

The most frequent uses of sensors we found while analysing the finished instruments are: use of the FSR to control pitch (8 instruments); use of the knob to control either pitch (8 instruments) or volume (4 instruments); and use of the button as an on/off switch (6 instruments) or event trigger (7 instruments). Both knob and FSR were mainly mapped through memoryless control relationships, where the current value of the sensor manipulated a current parameter value. Participants interpreted the FSR as requiring constant finger pressure, thus emphasising tangible and performative aspects of interaction. The knob was instead mainly used as a "tuning device" for the control of parameters constrained within specific ranges (e.g. to set the cut-off frequency of a filter). These approaches reflect the "inherent" continuous character of these devices as both FSR and knob produce a continuous electrical signal. Buttons were instead extensively used to either trigger random

events (mainly frequency values using the `random` object) or to switch on and off an audio signal (i.e. activating and deactivating sound processes by triggering the `line~` object to generate envelops or simply multiplying a signal by 0 and 1). We thus observed how the use of the button would indicate a "digital" understating of the device, as its output is restricted to two discrete electrical values.

These interpretations of sensors were often described as "obvious" by the musicians themselves.

> *P3: "yeah I mean that's the cut-off frequency, you would definitely use the knob because it gives you that control... [showing how to manipulate the knob] okay I can stop here!"*

Certainly, such "sensor thinking" is rather common within the music technology community and it is possible to trace back their multiple origins across both engineering and musical practice [264]. Indeed, we could observe how these compositional approaches follow the "grain" of the sensor technologies not only in regard to their functional and material qualities, but also thanks to the shared representations depicted by the majority of our participants.

> *P4: "with the pressure sensor ... the immediate thing I thought of controlling was pitch because that's just obvious."*.

While reviewing the interview data, we observed how previous experience with the sensors influenced musicians' design choices. Electronic instruments and interfaces (e.g. modular synthesizers and studio equipment) were often mentioned as precedent for design choices. P9, a live-coding musician and researcher in computational creativity, commented on the ways she encountered the sensors.

> *"I worked with hardware before, you see a knob and that kind of implies... if I think about how I would want to implement like a centre frequency I'll just kind of go straight to a knob"*.

P5, a PhD student working on collaborative music making with digital musical instruments, instead referred to his experience as student in a physical computing class while discussing the work of his partner.

> *"I find really interesting that you used the button to control the output of everything, while I used the FSR.. and the reason was that when I did the IDMT [Interactive Digital Multimedia Techniques] course here, usually we*

used the FSR to control the main volume... so I never thought like 'oh maybe I can use the button for that'... and you approached that in a really different way... and you've got a really different result, and I love it!".

Participants' previous experiences thus turned out to be influential for the interpretation of the sensors provided in our game, an understanding of musical devices that is both technical and cultural. These findings are in line with the notion of perceived affordances [284]: a design provides clues but "affordances can go unnoticed if they do not fit with real-world experience and cultural knowledge" [185, p. 179].

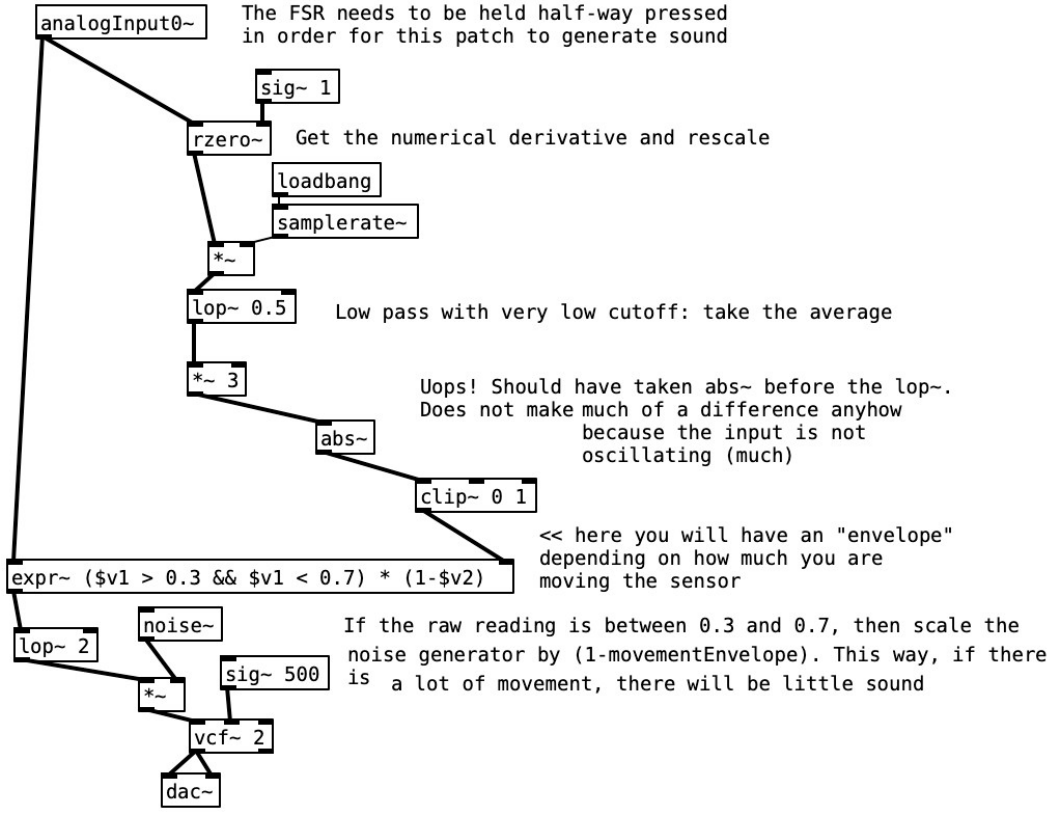


Figure 4.4: Implementation of a "hidden" sound control as "[t]he FSR needs to be held half-way pressed in order for this patch to generate sound". Comments are originals from participant.

We also identified a group of experienced Pd practitioners (P1, P2 and P12) that challenged the "obvious" interpretations of sensors often found in the work of our participants. These three musicians declared longstanding experience in the design of new musical interfaces for both artistic and research purposes. Moreover, they are affiliated with the same research group which focuses on the study and

development of novel musical interfaces. An example of such "unusual" sensor approaches relates to P2's idea of filtering and thresholding the FSR signal so that only a certain amount of constant pressure would activate a sound (Figure 4.4). This "hidden" control strategy requires fine sensorimotor skills to be discovered.

> *P2: "you need to find it! ... so you're supposed to press it halfway through and stand still."*.

P2 also implemented a basic memory-like algorithm for the button where the user must repeatedly press the sensor in order to increase the volume of a sound.

> *"if I press it once I just get a tiny bit, but if I press multiple times, I can keep it higher"*.

In this way P2 considers the activity of the performer within a specific time window of a few seconds and uses this information to operate the instrument, a strategy that expands the temporal frame of the interaction in contrast to the immediate and linear gesture-sound response which the sensor apparently suggested to most participants.

P12 instead processed the continuous signal of the FSR based on different timescales to extract three different streams of data, assigning them to different frequency values (Figure 4.5). This result was achieved using the `delwrite~` and `delread4~` objects.

> *P12: "I had the original signal, I had the delayed signal and then I had the signal that was the first two subtracted, and the delay is variable based on how much you're acting on the sensor"*.

P12's intention was to implement an algorithm that could take into account past interactions and obtain several rich (i.e. performatively meaningful) control signals. A one-to-many mapping strategy was also employed by P1 in order to manipulate a multidimensional feature such as timbre.

> *P1: "I just started with a sine wave and the FSR controlling the volume and then it was too simple ... then I had the FSR that also decides the incidence of this ring modulator ... so I can control the richness of the timbre and the volume"*.

Thresholding the continuous data, implementing time-dependent memory-like algorithms or obtaining multiple signals out of a single input value can be understood as attempts to escape to patterns suggested by the materials [259].

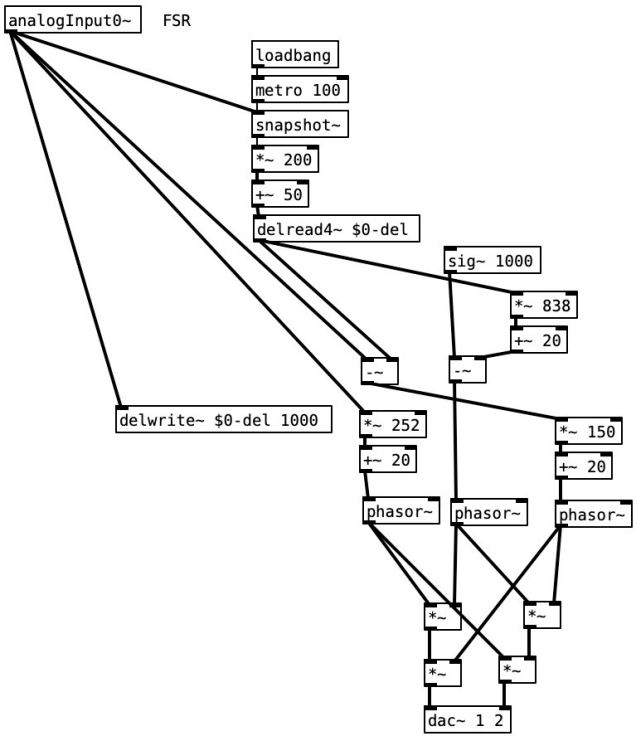


Figure 4.5: One-to-many mapping strategy; the FSR data is delayed and differentiated to obtain three different control values.

4.3.3 *Original and unconventional making*

While examining participants' reflections on the composition of the instruments, we identified a set of recurrent design concerns and values. 9 of 14 participants declared the intention of exploring creative and unusual solutions while composing the instruments.

> *P3: "[my main thought was] how can I make it sound stranger and cooler"*.

However, we could identify different attitudes towards the formulation of what would actually be considered as "original" and "unconventional".

Audio algorithms generating noisy, distorted and out-of-tune sonorities were also often considered peculiar and engaging. P10, a musician and technologist working as a postdoctoral researcher on the design of accessible musical instruments, comments on his aesthetic choices.

> *"I was trying to come up with a melody, but then I realised it sounded cooler to have it like slightly out of tune ... I just went for this sort of weirdly out of tune sort of sound"*.

Similarly, P13, a computer scientist and multi-instrumentalist with a passion for modular synthesizers, comments:

> *"yeah, I started by trying to do like FM between them I wanted to make ... a noisy thing with like weird harmonics and stuff"*.

Musicians self-identifying as beginners or intermediate Pd users often saw a lack of control as interesting and exceptional, for example designing and playing random and unpredictable sound processes. P3's comments on the sonic interaction developed by her teammate for the knob sensor is representative of such a perspective:

> *"I think there is no way for you to control it... which is really cool ... that's something you won't be able to control that good but at the same time it's a fun way of using the pressure sensor in a non like conventional context"*.

By contrast, other participants believed that building chaotic and uncontrollable processes was not particularly compelling. For instance, when P1 considered what he could have done differently for his sound design, he reflected:

> *"I would probably have had some type of random process, but again by having a random process generating pitches, it wouldn't have been so interesting ... it may be boring"*.

Indeed, some expert Pd users (P1, P2 and P12) exhibited interest in developing subtle and nuanced musical interactions.

> *P1: "it's not really [changing] the pitch and that's why I kept this idea ... because if this interaction would have resulted in a random pitch, that was clearly audible, I would probably delete the connection. But the fact that wasn't really perceivable but still it had a certain effect it was good for me"*.

The intention of designing hidden interactions that could be identified only through careful exploration was clearly a driving force. This manifests in the work of P12 and P2 who sought to compose the FSR in enigmatic ways where sounds should be discovered almost like "Easter eggs" in a video game.

> *P12: "I thought to try use the FSR like pressing it and then it wouldn't do anything until a delay had happened... or like trying to find a way for the FSR to be like a bit more mysterious" – P2: "you have to find it [the sound]! What that is doing is: we're looking for the offset to be between 0.3 and 0.7 ... and then if there's no variation you get the sound"*.

These tendencies exhibited by P1, P2 and P12 can be considered in light of two main factors: expert Pd proficiency and affiliation with a specific community (i.e. an academic lab active in the context of NIME research). These two circumstances seem to support the emergence of specific values and intentions towards the design of musical interactions. Indeed, we could not find approaches similar to those of P1, P2 and P12 in participants that did not share both conditions: we also recruited musicians with high level of Pd expertise but not affiliated to the aforementioned lab (P5, P11, P13) and members of the same research group (P7, P8, P10) who, although having similar experience in the design of new musical interfaces, identified as beginners or intermediate Pd users.

Overall, we saw how participants with different backgrounds occasionally would offer different (even opposite) views on the same sound design strategies. Most musicians saw the design of unpredictable sonic interactions as engaging, whereas a small group of participants were driven by different concerns: the implementation of subtle and concealed sound-gesture relationships. We would then argue that participants often recognised as valuable what the assemblage of Pd and sensors makes easy to design. We observed how the implementation of chaotic sonorities often emerged as a consequence of intricate patching. Indeed, one participant commented on Pd's visual immediacy, highlighting how the language promotes the creation of complex interconnections between objects:

> *P12: "there is this visual suggestion... you know, it's kind of screaming at you: 'connect everything to everything!' ".*

Another example of such easy-to-make procedure is the use of the button to trigger the `random` function and change the frequency of the `phasor~` and `osc~` objects. This approach, found in the work of 6 participants, produces apparently interesting musical results without implementing particularly refined mapping strategies. As we will see in the next section, the combination of these musical concerns and technical implementations has direct repercussions on the instruments' aesthetic outputs, often leading to their standardisation.

4.3.4 *Aesthetic considerations*

The most recurrent aesthetic comments provided by participants focus on the pitches produced by the instrument. Musicians mainly composed musical artefacts able to play pitches one after another, often selecting random frequencies within specific ranges.

P6: "I wanted it to go up to like the fifth or the tenth harmonic and then come back down and keep on cycling back and forth"– P7: "what I originally aimed to do was to confine it between about five different bass notes so that it could at least become some kind of melody ... I figured out the interval between these tones ... so that my thing that goes up and down always has the same intervals".

Amplitude was the other parameter most often considered while designing the interactions.

P6: "yeah I was just trying to get all the volumes balanced right at the end... because we had this really quiet and then this really loud and then this one was kind of in between".

If pitch and volume were often mentioned by beginners and intermediate users, expert Pd users tended to comment on diverse aesthetic matters. These include sound synthesis and effects such as timbre morphing, low frequency modulation, non-linear feedback, saturation and panning.

P13: "I wanted to do something more interesting ... just not to make another like pitch with an FSR"– P11: "I was trying for a kind of a panning modulation, so when you press the sensor it kind of switches the channel"– P2: "I modulated the amplitude on the two channels separately in positional phase so do you get some movements .. and I added a soft saturation here"– P12: "[I am] controlling the frequency of two detuned saw oscillators... so they're roughly the same and then when you hit the button it randomizes to a degree that frequencies, and then this is also controlling two LFOs ... they are all slightly detuned from each other so that's why you get this kind of beating".

Interestingly, we could also appreciate a similar aggregation of aesthetic concerns for the two musicians using SuperCollider. Indeed, compared to most Pd instruments (including some of those made by expert users), these instruments combine a great assortment of audio processes – e.g. comb filtering, phase modulation, compression and stochastic sequencing of note triggers. On the other hand, the sonic processes implemented in SuperCollider are characterised by a rather high degree of autonomy (i.e. the outputs of the instruments might change over time even without the intervention of the performer).

In order to get a better sense of the instruments designed by our participants, we spent some time playing them, thus exploring in detail their interactive and

aesthetic properties. The most prevailing modality of interaction embedded into the artefacts relates to activation and deactivation (on/off style) of unsynchronized sound processes. It follows that the amount of agency allowed to the performer is considerably constrained, as the majority of interactions are reduced to possibility of triggering or modulating different sounds. This feature also affects how musical events can be organised in time. The instruments collected are indeed bounded by an implicit temporal notion which facilitates immediate and linear gesture-sound interactions. Similar findings have been reported by Born and Snape [67]: Max users have little or even "minimal" influence while performing their patches. The impossibility of encoding sonic structures evolving through an extended period of time also recalls the notion of time identified by the "kind of time that Max is more readily configured to offer: a temporality in which musical events simply do or don't happen, without a coded sense of a musical past that can be recalled or a musical future that can be fast-forwarded to".

Once activated, the sonorities produced by the instruments can be categorised according the three sound sources exploited by participants. The artefacts using the `phasor~` object are generally distinguished by the production of continuous tones with distinctly perceivable noisy components. The instruments based on the `osc~` object tend to produce sororities associated with additive synthesis techniques. The instruments based on the `noise~` object instead tend to produce constant noise textures obtained through subtractive synthesis procedures. The latter is characterised by different bands of resonance due to the filtering of the noise source. These instruments allow continuous control of either cut-off frequency of the filter (pitch of resonance) or the noise amplitude.

Despite the variety of musical backgrounds and interests of our participants, the output of the various instruments exhibited a relatively narrow range of musical aesthetics. In general, the presence of noise is pivotal and rather constant. Despite considerable variation in the finer details of sound design, we found that the instruments are clustered around a few musical aesthetics which relate to experimental, noise and glitch music. The predominance of "raw" and "noisy" materials is certainly related to the limited amount of time our participants had to compose the artefacts. Nevertheless, we suggest that Pd actively supports particular musical aesthetics precisely because those aesthetics "organically" emerge after a few minutes of coding. We endorse the reflection posed by Born and Snape [67] while discussing the musical outcomes facilitated by the Max language: "[i]n a double bind, the technology that makes it possible for artists to forge unusual musical

practices also locates those practices within familiar and consolidated technical-and-aesthetic universes". In fact, these programming languages come from specific musical communities which are particularly concerned with electro- acoustic experimentation and "post-digital" aesthetics [301, 91].

The participants' final performances were also insightful for analysing the musical features promoted by the composed musical artefacts. Reviewing the collected recordings, we identified a set of aesthetic qualities that were not explicitly coded into the instruments but only emerged through performance. For instance, while exploring the complex spectrum produced, some participants were particularly keen to search for parameter settings that would produce harmonic relations between the various sounds. Harmonic tones would then be privileged through performance even if not explicitly composed. Another element that only emerged through performance was the discovery of speech-like articulations. This quality particularly occurs when pitch control is mapped to the FSR sensor.

4.4 DISCUSSION

The chapter discussion focuses on two main elements: makers' techno-musical backgrounds and the patterns tacitly promoted by the musical tools. First, we suggest that the design of a DMI entails an *in-situ* negotiation between designer and tools, arguing that musicians react to suggestions offered by tools based on their previous experiences and personal knowledge. We then consider how the artefacts resulting from such negotiation often re-purpose the musical values inscribed into the tools used in the design process, proposing that musical inscriptions can be regarded as highly recursive processes.

4.4.1 *DMI design as socio-technical negotiation*

Digital instrument design relies upon a vast set of emotional, cognitive and material processes which cannot be fully reduced to a few individual elements, such as the cultural issues examined in this chapter. However, our analysis suggests that musical ideologies inherited from specific communities and contexts are likely to affect the assembly of a new DMI. Examples of such "cultural translations" were provided by P1, P2 and P12, who focused on the composition of nuanced interactions, time-aware control strategies and hidden gesture-to-sound manipulations. Aside from being part of the same NIME-related research group, these

music technologists have broad experience in the design of musical interfaces in both academic and private sectors. Their approaches might be partly explained by considering their academic affiliation and previous professional experience as long-lasting involvement with communities of practice [218].

On the other hand, rather than aiming for specific musical ideas, various participants focused on the design of simple musical interactions easily achievable with the Pd language. Often participants had to simplify (if not abandon) more challenging compositional ideas in order to prioritise basic yet functional instruments:

> *P6: "my priority was to build an instrument that would definitely work first of all, then to give it some character".*

After having explained his original plans, P12 commented:

> *P12: "I couldn't think of a very immediate way to program that ... so I just used it [the knob] as a kind of trigger to create some randomness instead".*

P13 encountered some difficulties while implementing a complex FM synthesizer and therefore decided to simply multiply carrier and modulator signals:

> *P13: "but yeah it just was a bit more complicated to do the FM stuff so I just ring-modulated both".*

The difficulties encountered while implementing a given idea in a very short period of time might be in part related to participants' skills in programming with Pd. Nonetheless, our findings also suggest that the musical notions embedded into a given technology inevitably condition the work of the designers. Pd seems to promote particular programming styles where patching is often an exploratory and improvised practice, eventually producing rather unexpected results - see P4's struggle to explain his Pd work. The reuse of previously-made code blocks as well as the composition of hyper-interconnected and often convoluted patches are also intuitive procedures supported by Pd's visual interface - see the copy/paste routine described by P11. The reduced selection of sound sources and control strategies implemented by participants might be considered as further patterns promoted by the tools and materials provided. We also saw how Pd facilitated the implementation of direct, memoryless control strategies which activate and deactivate unsynchronized sound processes, as found in the majority of our participants.

This observation is supported by reflections from Pd creator Miller Puckette, who acknowledges that Max and Pd are fundamentally systems "for scheduling

real-time tasks" as their architecture is inspired on a "piano model" of music performance : "a collection of tasks running in parallel" whose timing is controlled by "wait functions and triggers" [300, p. 32] – an approach adopted to "make it easy to build patches whose behaviour is reactive" [301, p. 7]. Interestingly, Puckette also considers how these assumptions condition the musical interactions promoted by Pd: "the prevalence of over-reactive and over-obviously reactive pieces of live electronic music in today's repertory can be partly blamed, perhaps, on the fact that Max's and Pd's designs make it so easy to code up that sort of knee-jerk behaviour". Then "the user, if he or she adopts Pd, is adopting all this as part of the bargain" [301, p. 7].

Each instrument composed in our game offered a particular combination of musical qualities, where some can be associated to the technical and cultural background of the designer and others are instead promoted by the technologies used to assemble the artefacts. We suggest that the design of a new digital instrument is best viewed as a negotiation between designer and tools, a dialogue by virtue of which, in order to get something, each party sacrifices something else [121].

Although the tools contain hidden scripts and offer aesthetic suggestions, personal background, identities and aesthetic priorities still play a strong role in the outcomes. In this regard, the negotiations we are pointing at present strong similarities with those described by Green while engaging with the work of Di Scipio, where coding practices, social matters and musical identities interweave in a way that "the dynamics of the negotiation between the technical and social are [and become] a key aspect of electronic musical craft" [147, p. 59].

Despite providing participants with the same tools, the negotiation that occurred while composing the instruments resulted in different outcomes, even though they clustered around a few interactive and stylistic approaches. Each musician had a particular set of pre-dispositions, which emphasised or downplayed aspects of the technologies used in our research. Participants with different techno-musical backgrounds (including DMI design expertise and Pd proficiency) also offered opposite views on some of the musical interactions made more accessible by the tools – for instance, random based processes were interpreted either as eccentric and engaging (e.g. P10 and P13) or rather obvious and boring (e.g. P1 and P2). From this perspective, we might then say that we do not use a given music technology, but it is rather the instrument that uses the resources available in each of us, including our musical values and previous experience with musical tools and the cultures around them.

Due to short length of our exercise, the instruments created by participants may not reflect their ideal musical statement, but they do reflect what is easily achievable with Pd in a limited time frame. We suggest that even with a longer development time, the idiomatic patterns of the language and sensors will continue to exert an aesthetic influence on the creative process. At minimum, our observations provide an interesting take on the idea that "a computer music language should provide a set of abstractions that makes expressing compositional and signal processing ideas as easy and direct as possible" [255]. As many creators of languages explicitly focus on giving users "rapid experimentation in computer music" [367], they inevitably endorse certain procedures and techniques. By making specific routines more accessible (more immediate or easier), musical tools might also implicitly block (i.e. make more difficult) a great number of alternative methods and techniques.

4.4.2 *Recursive musical inscriptions*

In summarising the most salient traits we found in the work of participants, we do not aim to propose a general model of how the chosen technologies influence the design of musical interactions. We also acknowledge that our sample of 14 musicians is likely not representative of music technology practice as a whole. However, the artefacts composed in our game give us the opportunity to reflect on how musical notions travel from the workbench to the instrument. As discussed in Section 2.2.3, the *"formal logic"* through which a new technology refashions prior media forms has been described as a process of remediation [60]. This phenomenon implies that characteristics typical of an existing technology (whether technical or socio-cultural) are transferred into the new design.

The instruments examined in this chapter can be regarded as remediating musical values coming from preexisting musical cultures. For example, participants often interpreted sensors as either "continuous" or "discrete" and incoming data would then be interpreted accordingly. The comments by P3 and P9 on the use of the knob as a precision controller for fine-tuning are representative of the knob's cultural load, which might relate to its previous uses in telecommunication. Far from being absolute and *a priori* assumptions, these approaches to a sensor's possible interactions can be regarded as "received notions of what technology can and should do" [296, p. 382]. Indeed, the understanding of a sensor as either continuous or discrete can be linked to specific technological and musical discourses –

see, for instance, the reflections by Bill Verplank [356] on the *"handle"* and *"button"* control strategies or the mapping paradigms frequently adopted in NIME contexts [189].

The participants' tendency to compose and perform unpredictable noise-based interactions reflects many contemporary musical practices, including post-Cageian and algorithmic composition legacies. These stylistic features are also in line with the cultural contexts from which Pd emerged: experimental, electroacoustic and contemporary music. Indeed Puckette acknowledged that, throughout the years, the research environments he found at MIT Experimental Music Studio, IRCAM and the ICMC conference strongly influenced many underlying ideas behind Max and Pd [300]. In this regard, Horn describes how the overall experience around an interactive artefact can influence the design process as "individuals appropriate cultural forms and restructure them to serve new functions in light of shifting goals and expectations" [184, p. 117].

The instruments created in our compositional game repurpose musical assumptions linked to the technologies provided, sometimes also drawing on participants' own musical values. In case of Pd, while composing the artefacts, our participants indirectly engaged with Puckette's approach to the scheduling of real-time musical tasks. Puckette's approach was in turn influenced by the work of Max Mathews on the Music N and RTSKED programmes and Barry Vercoe on the Csound language [300]. We can thus see how the identity of an instrument emerges from a process of *recursive inscription* from successive generations of musicians and technologists. We could apply this rationale to discover the cultural values inscribed into a given digital tool as it results from previous socio-technical negotiations and assemblages, not only recovering the technical and musical influences of Pd, but also the influences of those earlier technologists and musicians, and so forth.

Overall, our reflections tackle a well-known topic of discussion within the domains of technology and media studies: "we shape our tools, then our tools shape us" as the saying goes. This argument has been supported by many authors throughout the 20th century – see amongst others see the notion of "technogenetic spiral" introduced by Katherine Hayles [171]. Our investigation seeks a more specific account of the idiomatic patterns of particular technologies commonly used in NIME design, aiming to shed some lights on how musical ideas are embedded into musical tools and travel from on technology to another.

Through our research we could appreciate how the designer may temper some of their abstract ideas to create what is perceived to be feasible with the available

tools, time and skills. Just as an improvising pianist may reach for chords that fit easily under the hand, the tool will suggest certain ideas which can then be accepted, rejected or modified by the designer. The influence of the technology in turn puts the focus on the designer of the specific technology used, who is responsible for shaping its scripts and embedded values [4]. The tool creator may in turn be influenced by their own communities of practice and use of technology.

The process of recursive of inscription here introduced is not unique to digital tools, but we suggest that digital technology enables the process to proceed exceedingly quickly due to the countless socio-technical components assembled into every digital artefact – see the "quantity affects quality" arguments introduced in Section 2.2. Due to this cultural load, digital music technologies will inevitably influence future users, which will re-negotiate the notions embedded into the instrument based on their own embodied practices, subjective views and cultural affiliations. Grusin notes that "mediation is always a form of premediation, of generating a multiplicity of potential but never fully formed futures which will have real impacts on life or action in the present whether those futures actualise themselves or not" [151, p. 141]. According to this perspective, the creators (and contributors) of widely-used music hardware and software tools might indirectly turn out to be some of the most influential musicians of our time.

4.4.3 *Methodological considerations*

As noted by Puckette [301, p. 8] the design of digital tools for creative purposes *"requires long and serious thought about the implications of what we are making and doing"*. As this reflection is essential for the design of novel digital instruments and music interfaces, it seems timely to ask how music technologists should engage with these kind of investigations.

The diverse theoretical and methodological perspectives found in research contexts such as STS and RtD might provide researchers with a broad range of approaches to unpack computer-mediated musical interactions, including autoethnographic and art-based methods [237, 203]. A interesting direction of research certainly relates to the systematic comparison of different music technologies at work. In this regard, we highlight the importance of moving beyond the quantitative evaluation of musical tasks, to reflect on the aesthetic and cultural situatedness of musical tools. Is indeed our conviction that the concerns posed in this chapter require qualitative mindsets able to analyse the use of tools and materials on differ-

ent scales - e.g. zooming in design and performance practices, but also considering the broader musical and socio-cultural ecosystems from which they emerge.

Despite the variety of perspectives at play, the "measure, model and evaluate" attitude seems to prevail within academic music technology contexts; an approach that, as noted by Hayes and Marquez-Borbon, is often functional to the quantification and economisation of research performance [170]. In a culture where technological development and innovation are often considered as ends in themselves, funding bodies and government agencies seem more inclined to facilitate certain disciplinary approaches over others.

Rather than offering extensible and quantifiable knowledge, the research presented in this chapter provides a possible interpretation on the ways music technologists engage with their tools. Our contribution is based on in-depth observations and reflections limited to a small set of computer music practices and instruments. Furthermore, far from being a neutral tool for musical expression, the Bela platform used in our game introduces a further technological influence that is not the focus of our analysis. As authors, we also cannot claim cultural neutrality in our analysis, though we present in previous sections an analytical process that seeks to minimise bias. We are linked to the same academic groups as some of our participants, and we are closely involved in the NIME research community. Rather than claiming detachment, we instead suggest our situated outlook might enable a deeper understanding of the musical practices considered in this chapter, but it will also influence our reflections [172].

The musicians involved positively commented on the study, generally describing it as a fun and entertaining game. Nevertheless, after introducing the activity, it was occasionally possible to perceive that participants felt the pressure to design "good enough" interactions. Especially, Pd beginners were sometime scared to not be able to design any sound at all out of such limited amount of time. In these cases, we found useful to remind participants that the study is not about assessing their level of expertise with Pd and that any attempt, even a Pd patch that does not produce any sound, is valuable for the research. Also, reassuring participants about the possibility to use help files, manuals or examples from the internet generally helped to lower the tension.

In general, the tension decreases for beginners once they get to compose the second sensor, i.e. when they understand the logic behind the game and eventually realise that they are actually "able" to complete the task requested. However, true

relief and amusement generally arise during the final performance, when musicians can demonstrate their work. In this phase, the enthusiasm of participants showing and commenting the musical interactions co-developed is indeed palpable. This suggests how valuable music performance can be for research purposes: play as a generative and shared practice that can stimulate critical discourses and confrontations.

The playful and permissive approach adopted in our activity proved to be an effective strategy, which facilitated the difficult task of designing functional musical interfaces by pushing away design pressure and compositional anxiety. As suggested by Owen Green, we found it particularly useful to exploit what musicians are obviously good at: playing (and designing) an instrument [149]. Indeed, we noticed that asking musicians to perform facilitated the communication of technical and musical issues, and while performing, our participants could fully explore the composed musical interactions and discover sonic gestures that were not explicitly encoded into the artefacts. We also identify as a key element the choice of dividing our exercise into small, short steps. This approach made our activity more accessible, especially for those participants less experienced in the design of creative sonic interactions.

Finally, we wish to draw attention on the fact that COVID-19 impacted the research presented in this chapter. In short, during the first lock-down period, it has been essentially impossible to run in-person studies and collect further homogeneous data. Since we could not longer involve new musicians, there is little comparison in our research between different audio programming languages. Nevertheless, just before the pandemic, we were able to recruited two very skilled SC users and this allowed us to introduce some comparative elements. For instance we could appreciate how, compared to the Pd, these two SC users tended to reduce the performer's control to privilege the autonomy of the algorithm. Indeed when the two SC instruments are switched on, sound variations occur without anyone controlling them directly.

Other languages might then support different interactive patterns and aesthetics. For instance, we suggest, Max might have facilitated the playback and real-time manipulation of sound files – an approach that we never saw in the Pd instruments – as it is possible to load samples by simply dragging and dropping them into a patch. Participants using Max might also have benefited from the extensive curated

material it is possible to find in Max documentation (e.g. help files and snippets) as well as from the internet (e.g. tutorials, externals and packages).

4.5 CHAPTER CONCLUSIONS

This chapter has introduced a study exploring the ways in which digital musical systems are non-neutral mediators of creative thought. Specifically, it reported on a compositional game in which sound designers were asked to sketch simple instruments with common electronic sensors and the Pure Data programming language. By identifying a set of recurrent patterns of the resulting instruments, we began to reveal the latent influence of these tools.

Our findings present great affinities with Born and Snape's ethnography on the Max audio programming language [67], showing that Max and Pd *"can be considered as extended implementations of the same paradigm"* Puckette [300, p. 31]. A major difference compared to the work of Born and Snape, is that our research also considers the reflections shared by Puckette on his own designs – including his main sources of influence and the resulting musical patterns facilitated by Pd [301]. Our analysis often confirmed Puckette observations, which in turn, became key elements for our discussion, allowing us to interpret and contextualise our findings within the socio-cultural frameworks out of which Pd emerged.

The investigation presented exploited making as a means for speculation and reflection as participants are invited to unpack their actions, disclose design intentions and priorities as well as consider the results of their work [322]. This, based on the idea that embodied making processes facilitate a particular form of thinking [10]. Overall, our approach proved to be rather effective to discover both makers' felt experience and the influence of the technologies they used, providing us with a set rich and composite insights on design practices and technological agencies.

Our musical game was deliberately time-limited and highly constrained in its physical materials. We do not propose that the instruments created reflect what any of the designers would do in a longer and more open-ended situation. It may be that certain kinds of sounds and control strategies are simply not achievable from first principles within 10 minutes. In fact, this underlines our argument on the idiomatic patterns of the tools. That certain musical interactions recur in the work of several designers with varied musical backgrounds further confirm the aesthetic influence of tools and materials.

Designers sketching simple instruments using a limited palette of sensors with the Pd programming language approached the task with creativity and style. Within the diversity of individual outcomes we frequently saw recurrent patterns in musical language as well as the design of controls and audio algorithms which appear to reflect the arrangements of the tools. The considerations introduced in this chapter are also strengthened by the design fiction exercise introduced in Chapter 3 as we found that practitioners involved in the music technology communities conveyed a variety of musical values through widely differing types of non-functional artefact. Thus the level of consistency across the simple instruments in this activity is notable. It is unlikely that each person's musical intentions would lead them to simple oscillators with linear frequency controls; rather, we are seeing a strong influence from the technology.

Overall, the work reported in this chapter investigates the patterns digital music tools suggest. We introduced a possible approach for questioning and recognising their influence, and provided an interpretative account to frame some of the modalities through which tools and materials shape the design of our instruments.

5

ON ABSURD MAKING AND PERSONAL DESIGN KNOWLEDGE

This chapter incorporates significant material from 'Useless, not Worthless: Absurd Making as Critical Practice' by Lepri, McPherson and Bowers originally published in the proceedings of the Designing Interactive Systems Conference, DIS 2020 [229] and 'Play Make Believe: Exploring Design Fiction and Absurd Making for Critical NIME Design' by Lepri, McPherson, Nonnis, Bennett, Andersen, Stapleton, Mudd, Topley and Bowers, accepted workshop proposal at the International Conference on New Interfaces for Musical Expression, NIME 2020 – presented as '10.000 Musical Instruments for a Semi-connected World' [230].

The work introduced in the this chapter focuses on the individual perspectives brought in by practitioners engaged in the design of digital musical instruments. In particular, I present two activities organised around the themes of absurd musical interfaces, questionable sonic interactions and unworkable music designs. These research gave us the opportunity to elicit and make manifest two primary sorts of personal design knowledge: the critique of conventional practices and ideas in music technology research, and the ideation of instruments beyond familiar paradigms linked to everyday objects and tools.

First, I report on the outcomes of the *Unuseless Music Design* hackathon, a project exploring absurd making as a way to support critical and disruptive design practices. Second, I describe the *10.000 Musical Instruments for a Semi-Connected World* workshop, a collaborative online event conceived as an unconventional experiment to generate interface ideas and speculate on music technology through open-ended artefacts and playful design explorations. The chapter concludes with a methodological reflection on how make-believe, fragile and absurd design approaches might stimulate individuals' musical creativity, unlock unconventional musical visions and reveal critical perspectives on technology development.

The investigations presented in previous chapters explored how musical communities and digital tools situate and mediate the assemblage of DMIs. Both works illustrate the entwining of making processes, materials and social contexts by attending to the instrumental and creative practices of different musicians. Overall, participants responded to our musical invitations with inventiveness and originality. The artistic intuitions and resources brought in by each subject can be considered as the lifeblood of our studies, without which they would have resulted in a series of flattened and homogeneous routines.

In view of the relevance that personal techno-musical visions had in all the stages of the work previously introduced, this chapter focuses on the personal perspectives practitioners inevitably ascribe to the use and development of musical interfaces. Our intention is then to scrutinise a strategy for the discovery and highlight of subjective connotations and significances. This additional step will broaden our analytical framework and allow for a further level of awareness over the intricate processes behind the emergence of digital instruments.

In order to make evident and visible personal and intuitive design positions we decided to experiment with a playful and provocative approach based on the composition of absurd, questionable and unworkable instruments. The idea of exploring absurd making to disclose musicians' individual knowledge and insights was also largely inspired by the fictional ventures at the basis for the studies presented in Chapter 3. Indeed, the research here presented follows the line of work outlined by Andersen with the Magic Machine workshops, where the making of highly subjective fictional instruments allows participants to create personal design ideas which function as "anchoring points for conversation and discovery" [14, p. 3].

The work here presented aims to further exploit the cheerful approach described in the previous chapter: rather than searching for shared values and assumption, we consider the potential of playful, fragile and silly making for engaging with subjective and critical narratives linked to the lived experience of music technology practitioners. In this context, we borrow the term 'lived experience' from Shear and Varela implying that "the process being studied ... appears as relevant and manifest for a 'self' or 'subject' that can provide an account; they have a 'subjective' side" [p. 1][325]. In the context of our research, the "subjective factor" then relates to the individual understandings of the "musical absurd". By framing the "unreason-

able, unsound and incongruous", musicians were encouraged to arrange design statements in resonance with their own background, temper and knowledge. The permissive, lighthearted and open-ended qualities of our research then facilitated the emergence of subjective interpretation: a view of the absurd from a particular angle which both sets and hijacks what practitioners perceived as ordinary and familiar in music technology contexts.

The discipline of imagining and building illogical, unfamiliar and overly complicated machines has long been practised by both artists and inventors (see Rube Goldberg, Heath Robinson, Simone Giertz and Joseph Herscher - to name a few). A well-known reference of absurd design ideas is Jaques Carelman's *Objets Introuvable* (see Figure 5.1) [89] which include the teapot with the handle on the same side as the spout – an image often used for the front cover of Don Norman's *Psychology of Everyday Things*. Often mentioned in design contexts, is the Japanese art of Chindogu, where a designer produces "un-useless" objects [55] which are, from a practical point of view, (almost) completely useless [208].

Figure 5.1: An example of Objets Introuvable (unfindable object) by Jaques Carelman: Bicyclette-Harmonium - Catalogue of Extraordinary Objects, London, 1971.

In HCI contexts absurd and questionable strategies are often exploited to support the generation of new design knowledge – initiatives that often relate to the RtD realms introduced in Section 2.3. Vines et al. facilitated participatory design workshops by exploiting the notion of *questionable design concepts* [357]. The research team proposed to their participants a speculative exercise based on a selection of design concepts that were "not conceived to be entirely frivolous but

neither were they thought of as in any way finished or likely solutions to the problems they sought to address". Thanks to this mix of serious and playful design proposals, participants were able to reveal personal views, providing suggestions, reflections and articulated rejection statements. More recently, Laura Devendorf and colleagues questioned the assumptions and expectations that qualify a conventional HCI contribution by exploring what a "non-contribution" could look like [109]. Drawing affiliations with Fluxus' artists and practices, they experimented with a set of open-ended design strategies and unsettled artefacts illustrated as HCI-amusement.

Within the domain of musical interactions, it is possible to identify a small but growing body of research that challenges technology ideation and development through absurd and playful artefacts. These include the work of John Bowers and Owen Green which exploited the notion of "hijacking" as a way to question existing music technologies, their customary range of application and the implicit norms of musicality codified into the artefacts [71]. As a means to critically engage with current machine listening techniques, Bowers and Green build provocative music designs such as disagreeing pitch trackers, re-de-reverberators and eternal resonance machines. These were then collected in the form of an annotated portfolio [69] to outline the critiques and upshots emerging while designing and using the various makings.

This chapter offers an overview of the insights we were able to learn while reflecting on the making of unconventional artefacts. In particular, we describe absurd making as a source of critical and creative thought which is "primarily owned and governed by the individual and forms part of their evolving personal reflection, stance and position" [14, p. 11]. The following sections describe the *Unuseless Music Design* hackathon and the *10.000 Musical Instruments for a Semi-Connected World* workshop, two events organised around the themes of absurd musical interfaces, questionable sonic interactions and unworkable music designs. A selection of artefacts produced during the events are presented in order to provide a sense of the technological puns, games and reflections that emerged in our research. Finally, the chapter discussion considers how absurd making can be regarded as a valuable approach to generate personal, divergent and critical design reflections.

5.1.1 *Research questions*

The work introduced in this chapter addresses the following research question:

How can we unveil the personal design knowledge and views brought in by practitioners engaged in the DMI practices?

Particular questions we address are:

- How can we make manifest subjective intuitions and narratives for the ideation and development of musical interfaces?
- How can playful and open-ended design activities be exploited for the discovery of personal design perspectives?
- How can we explore unconventional, critical and diversified visions on NIME practices beyond the paradigms imposed by current music technology?

5.2 ABSURD MUSIC HACKATHON

The hackathon took place over two days at Queen Mary University of London. A public call was circulated through academic mailing lists and social networks. Interested candidates were required to submit a short written proposal outlining an unuseless music design to be developed during the hack lab. Proposals also included a short summary of candidates' musical/artistic background, skills and motivations to partake. A selection of participants was conducted based on the quality of the idea - i.e. originality, silliness, unuselessness, style and achievability, and the candidate's background - while aiming to balance a multidisciplinary convergence of people. Moreover, we considered the applications a good way to understand participants' interests and they were used as starting points for the later brainstorming/discussion that happened during the first day (see Figure Figure 5.2). 27 participants took part at the event - 12 male, 15 female, median age 32, age range between 23 and 50.

Figure 5.2: Participants brainstorming absurd musical ideas.

5.2.1 *Hackathon facilitation*

In order to support participants, two external mentors, John Bowers and Hannah Perner-Wilson [1] were invited to join the event. These guests have significant experience in the fields of e-textiles, music technology, craft, research through design, DIY, absurd making and other related fields. The mentors were on site for the whole duration of the workshop, guiding and challenging participants from both technical and theoretical viewpoints, while occasionally making their own absurd designs. Mentors contributed to shape and tailor various activities. During the course of the event they each delivered a short seminar around the hackathon's theme and an introduction to e-textile materials and practices. To provide participants with a good range of tools and incentives, we also provided basic training on the Bela music maker platform [260].

The aim of the hackathon was to design absurd musical propositions using the tools and materials usually found in design and craft workplaces. The tools and materials provided included digital fabrication tools (2D design tools and laser cutter), traditional workshop tools, music maker platform (Bela board), low-cost circuitry and sensors and e-textile materials and tools. Participants were encouraged to bring any particular tools or materials and use any free or open-source resource. During the first morning we organised a brainstorming session based on the absurd ideas and concerns articulated in the various applications accepted.

1 See John Bowers and Hannah Perner-Wilson websites - last access April 14, 2023.

Although participants were free to work on the concept previously submitted, we encouraged attendees to share their ideas, gather skills and collaborate for the making of similarly useless projects. By the end of the morning, participants were able to choose an individual or group project.

The event ended with a final round of presentations and short performances in which each project was shown to the other participants and a small audience of colleagues and friends. We recorded all the presentations (audio-video) and, before this concluding act, we also interviewed all participants asking to tell us about their projects and the notion of absurdity behind their works. We also collected demographic data including academic, creative and technical backgrounds, age and gender.

5.2.2 *Useless (but not worthless) music designs*

One of the outcomes of our event are the produced artefacts themselves. The various designs are here presented following the principles of annotated portfolios [69]. In this way, we aim to communicate, in a descriptive yet generative and open-ended fashion, a selection of themes and issues related to the absurd artefacts which were designed. In the spirit of annotated portfolios, we hope that the themes and the artefacts mutual illuminate each other to show the sense of absurd design that emerged in the hackathon. In the following subsections, we will often directly refer to the authors' statements, quoting either their comments on the artefacts – collected during the hackathon – or the concepts and ideas they proposed in the application forms.

The artefacts introduced in this chapter are then organised according to the following thematic areas:

- Unworkable Materials & Tools
- Impractical Bodies
- Musical Pitfalls
- Beyond Human Music

During the event participants developed 18 absurd projects. For a complete overview of the project developed see the hackathon web-page (last access April 14, 2023). The artefacts below presented have been chosen as the most representa-

tive of the themes above mentioned and those omitted can be associated to one or more of these conceptual domains.

Unworkable Materials & Tools

Several of the hackathon's projects suggest reflections over tools and materials. *Parfileuse* is a e-textile project based on *"17th century embellishment techniques"* (see Figure 5.3). The piece reinterprets in an artistic setting the act of removing precious metal threads from clothes and vests which has been performed for centuries *"either as an act of recycling or as an act of theft"*. The embroideries are then *"explored as a tool for performance"*: connected to an audio circuit and taken apart during the performance. While de-composing the needlework, the artist composes sounds in real-time. The main absurdity here is *"the labour that goes into making the embellishments which are then taken apart by the same person who did it"*. Since *Parfileuse* is a sonic interface that vanishes while it is played, the piece might relate to the elusiveness of music and performance art along with their aesthetic and significance.

Figure 5.3: Parfileuse: an artwork based on 17th century embellishment textile techniques. The artistic research culminates with a final performance in which e-textiles connected to audio circuits are disassembled after many hours of labour.

Nevertheless, *Parfileuse* might also invite us to reflect on craft practices and the precariousness of the objects we create. Such considerations might align with the research on the material turn in HCI, where designers are particularly concerned with the experience of living materials [304]. The single materials constituting an artefact might have a much longer life than the one of a specific *composition*, as

trees grow for years in the forest before being used for a furniture [110].

In this regard we saw many projects that took an exploratory view of material qualities as a starting point. For instance, we witnessed a considerable number of e-textile explorations (almost half of the projects), which was expected given the featured introductory activities and the background of the participants. One of these projects, inspired by the art of Origami, is a first prototype of a wearable sensors to control sound synthesis (Figure 5.4). The interface is conceived to detect joints such as wrist and elbow articulations and, according the authors, future development might result in an interactive music system in which, like puppets and marionettes, *"the performer can be moved/played by someone else"*. Besides the silly idea of having a *"performer that does not play but it is played"*, we were captivated by the fact that both physical and digital properties were tightly considered together as if they were composite materials [353]. The inter-dependencies between textile properties, sensors arrangement and sound mapping clearly emerged since the early stages.

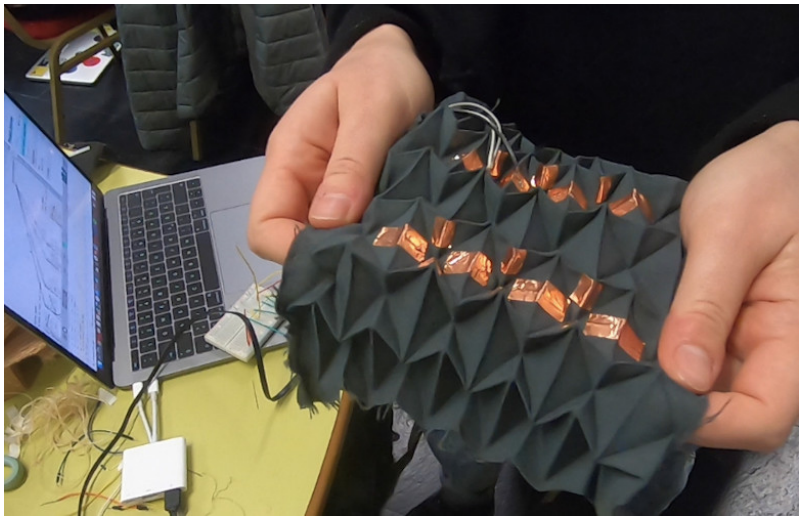


Figure 5.4: E-textile materials exploration inspired by the art of Origami: wearable sensors to control sound synthesis. To become an interactive music system in which the performer can be played by someone else.

Some participants instead steered their projects towards the making of overly complicated sonic machines. For instance *The Winner "repurposes a vintage claw crane motor usually found in arcade games"* to grab an e-textile sensor which then produces a sound. The user can only operate the system with a single button that

opens and closes the claw. It is not possible to move the claw which is located exactly on the top of the fluffy object that should be grabbed. In practice the user presses a button and makes a sound, however, from a technical viewpoint, this action passes through various layers of completely useless steps.

The author explained that the artwork is based on the notion of *"expectation"*, thus making an arcade-like game which *"is almost impossible not to win"*. This work then raises questions for strategies of design which emphasise efficiency-driven approaches to creative technologies that apply videogame-style motivations and rewards to creative and aesthetic practices [267], while highlighting the importance of the complex interplay of anticipation and frustration to interactive experience.

Impractical Bodies

The Patroniser & Vinip (see Figure 5.5) are two pieces of wearable sonic interfaces *"built to provoke uncomfortable situations"*. *Vinip* is made of an interactive bra that responds to different gestures (e.g. stroke and press). *The Patroniser* is a hat which, as a sort of giant press button, detects when someone pats on it. The hat touch sensor was made out of two layers of conductive fabric separated by anti-static foam, while the bra's nipple area is made responsive using woven non-conductive and conductive material strips.

Figure 5.5: The Patroniser & Vinip: two wearable instruments designed for uncomfortable interaction i.e. nipple squeezing and hat patting.

These two e-textile designs deal with an idea of social interactional appropriateness and trouble. Sonic interactions, where body gestures such as scrubbing, squeezing and patting, become *"something that put you in a weird and awkward place"*.

The Patroniser and *Vinip* raise a *"critique of technology for leisure and satisfactory experience"* exploring the notion of *"uncomfortable interactions"*. With its focus on social embodied conventions these artworks invite us to rethink what is permitted with our bodies (including their objectification and commodification), what are the values we associate with them and how they can be integrated in the design of new technology [182].

A similar set of reflections is conveyed by the *Pompom Swatches* sound interface in Figure 5.6. These belong to a family of instruments made of knitted balls, to be *"positioned in awkward places and played through non-conventional gestures"*. In this particular implementation the interface is placed on the floor and, as a sort of magic sonic carpet, it can be performed by different bare-foot people simultaneously. This soft and colourful sound art work offers *"the opportunity to make, play and collaborate"* exploring unusual body interactions for music performance. These funny hand-crafted pompoms seem indeed to privilege active participation and physical presence through the combination of accessible materials, tangible interactions and sonic environments.

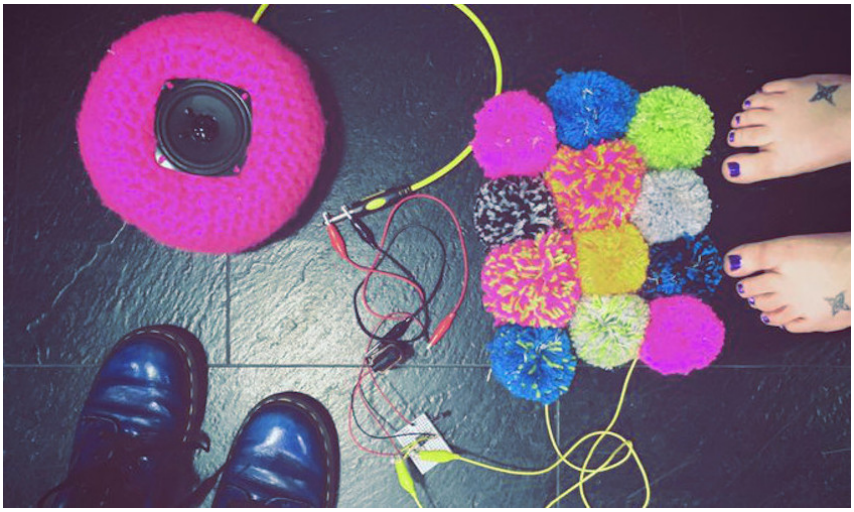


Figure 5.6: Pompom Swatches: knitted balls, to be positioned in awkward places and played through non-conventional gestures.

Participants produced various other projects concerned with impractical and idiosyncratic body interactions. These seriously silly artworks include *"an instrument that only works against gravity - where the musician is able to listen to what is s/he playing [only] when both feet go above the ground level"* - and an interface for dance

performance inspired by *"non-doing activities such as meditation and relaxation"* in which body movements are used to shake jelly sculptures (sympathetically called by some participants *Dancing with Jelly*).

Musical Pitfalls

As we expected, several projects focused on questionable sonic interfaces directly relate to current music technology and its implied values. Nonetheless, the critiques emerging from these artefacts can easily be applied to broader HCI contexts which might not be directly related to the development of technology for creative practices.

Figure 5.7: Anyone can Make Music: an oversimplified instrument that plays poor-quality music with the press of a giant red button.

Anyone can Make Music is the solution to music making that nobody was waiting for – see Figure 5.7. The designer explains that *"thanks to the latest digital technology, anyone can make music. This instrument solves your problems. It lets you make music when you could never make music before." Anyone can Make Music* is a self-contained instrument shaped like a pair of music notes, featuring a speaker and a giant red button. Pressing the button causes the instrument to play a random excerpt of a crude MIDI rendition of Pachelbel's Canon, chosen to be the most *"insipid"* possible musical material. A selector switch allows the performer to *"make music in any style"* by choosing between 5 different MIDI arrangements of the Canon.

The hyper-reductive instrument offers an explicit critique to many crowdfunded commercial instruments, whose campaigns often claim that new technology is the answer to enabling people to make music, while devoting relatively little attention

to the kind of music that the instrument makes and whether this music aligns with the aesthetic values of the would-be performer. These projects often ignore the importance of time and embodied practices while learning an instrument. The risk is then to present misleading user-friendly interfaces that promote the illusion of a technology characterised by a "low entry fee with no ceiling on virtuosity" [372]. Notions such as "technology democratisation" and "accessible tools" become functional to marketing campaigns and part of well-defined business strategies.

Figure 5.8: MusiTex: featuring a mute kazoo that converts kazoo to text (for silent practice) and a banana to text instrument to accompany the kazoo.

MusiTex is instead a collection of musical artefacts that permanently *"solve the age-old problem of making too much noise with musical instruments"* by replacing sound with text. The different designs developed within the *MusiTex* framework feature e-textile bouncy sensors, tongue in cheek genre recogniser (e.g. "gentle banana metal") and various applications based on pool noodles. Another interesting *MusiTex* instrument implements an advanced artificial intelligence technology to convert the sound of a kazoo into text. *"The instrument's paper membrane is replaced with a piezo mic, allowing the air pressure to be monitored. With a focus on the textural rasps and timbre of the kazoo, these are converted into a form of rapidly generated noise poetry: brwwwzz.. bwz.. bfwwzzz...zbf.. zbfff"*. To be more appealing for the market the banana feature was introduced – see Figure 5.8. It is therefore possible to accompany the kazoo and intensify the complexity of the verses generated. *"Since sounds are*

fully represented as written composition, the instruments can be played in nearly complete silence, opening up new methods of performing and enjoying silent music".

Overall, the *MusiTex* collection made us think about two main considerations. The first relates to the fact technologists and researchers are often keen to advance explanatory models of music that inevitably fail to grasp the composite, situated and often inscrutable nature of art. Highly sophisticated technological advancements might then result into naive symbolic and abstract representations that, once put in practice, ignore the specificity of contexts and generate rather poor outcomes.

The second refers to the understanding of music as an entity that should be solved. The *instrumental rationality* common in technical problem-solving within science and engineering is essentially interested in the design of *better technology* regardless its actual context of use [129]. Accordingly, this approach tends to consider artistic contents as battlefields for the training of the latest technology that, if powerful enough, will prevail over its competitors.

Another group of participants decided to design giant music interfaces. The *Pipe Technology* project (see Figure 5.9) magnifies standard music controllers and uses them to control unpredictable and chaotic sonic engines. These *"latest frontiers in high definition technology"* allows us to *"expand what previously was really small"* into interfaces that *"could be controlled with one finger now require full body movements"*. How does music production and performance change if we use 1.5 meter long sliders and knobs with 1 meter radius?

Through their satirical and playful stances, these kinds of projects relate to contemporary technological trends and incite us to wonder about different design strategies we could consider. For a long time, the miniaturisation of technology is a key driving force behind technological development and clearly it brings many useful aspects. However, the *Pipe Technology* project opens up a design space in which the shrinking of technology is not a prerequisite, an intuition that might let us discover musical alternatives and new aesthetic opportunities through the exploitation of full-body sonic interactions.

Finally amongst the many impractical projects concerned with musical matters, it is worth mentioning the *MIDI Uncontroller* - a MIDI keyboard designed to *"minimises performance anxiety"* by taking control away from the musician: once the performer press a key the machine plays a random sounds at a random volume -

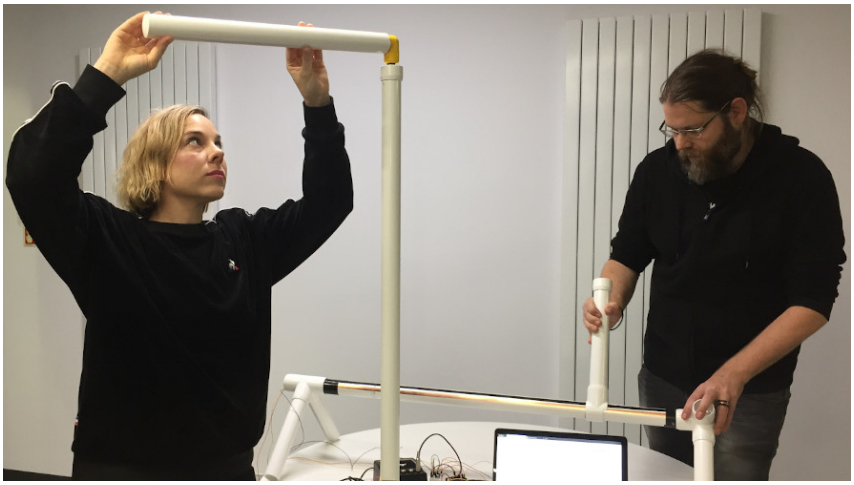


Figure 5.9: The latest innovation in Pipe Technology: a project that magnifies standard music controllers allows us to expand what previously was really small.

and *The Bee* - a stretchable guitar strap that modifies the music produced by the instrument (i.e. a seriously silly bee sound).

Beyond Human Music

The Bug Orchestra is a fully equipped art residence facility for robotic bugs (see Figure 5.10). These amenities include *"a dance floor, a red carpet, a rave area and a death trap"*. The aim of the project is to create an environment that could *"adequately stimulate bugs' creativity, give them compositional freedom and eventually music performance training"*. Opportunities for sound-making are then implemented with a camera tracking the robots' movements and with a piezo mic detecting their dance steps. The paths the insects take around the residency then modulate electronic sounds. Overall, we can say that the facility - designed to *"eliminate procrastination, stage fright and writer's block"* - positively influenced artistic production of the guests who took to hackathon's final round of presentations with a captivating music performance.

Another project concerned with animal issues developed during the event is a sonic interface inspired by Narwhal whales (see Figure Figure 5.11). The questions behind the project can be formulated as follows: *"if you were in the depth of the ocean, where there is no light and no vision, how you might explore your surroundings? How would you communicate with friends and neighbours?"* The interface assembled featured a horn that can both sense the environments and detect the head move-

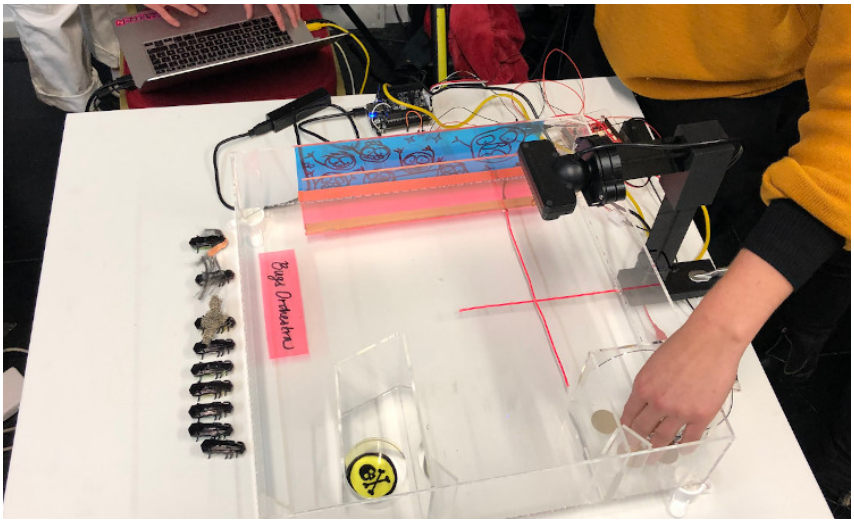


Figure 5.10: The Bug Orchestra: a fully equipped art residence for robotic bugs. The facility is designed to adequately stimulate bugs' creativity, give them compositional freedom and music performance training.

ments of the person that is wearing the instrument thanks to two touch sensors placed at the two ends of the horn. The interface also blocks the user's sight since it aims to reproduce the Narwhal whales' habitat.

These projects share an interest to explore technology that goes beyond the human-centred paradigms and explore playful approaches which consider different ecologies and somehow de-centre the human as part of design process and outcome [362]. These works displace or re-situate human agency within more extended ecologies which recognise forms of machine vitality. As such, they highlight creation processes which engage with topics such as shared autonomy and non-human interactions. We see these conversations more and more frequently in HCI, and amongst them we spontaneously relate our absurd projects to the debates around the ethical issues we might face while considering animal-computer interaction [246]; thus taking into account the animal perspective might help to advance a debate that, even if has never entered mainstream in HCI, has extensive ecological implications.

5.2.3 *Hackathon discussion*

In this section we aim to elaborate on the nature of absurdities encountered in our hackathon. Rather than deepening the analysis of each single project, we aim

Figure 5.11: A sonic interface inspired by Narwhal whales. To be used in the depth of the ocean to explore the surroundings and communicate with friends.

to expand on the different kinds of interferences and dissonances we can observe across the corpus of projects developed in the hackathon. By revealing some underlying mechanism (i.e. identifying the dissonance) we hope to partially disclose the intentions and reflections of the participants. However, far from being fully explanatory, the interpretations of absurdities introduced in the next sections might apply to more than one project, each time with slightly different connotations.

Our discussion then focuses on the following techniques developed by participants to create musical contradictions:

- Paradox
- Hyperbole
- Suspension
- Oxymoron

Paradox

Many of the artworks developed during the hackathon convey paradoxical accounts. Paradoxes are statements that run contrary to shared expectations, trends or assumptions. The embroidered e-textile embellishments of *Parfileuse* might be a good example of such a mechanism. After many hours of precise and intricate labor, the artist de-composes them to produce sound during a performance. The assumptions we might have on craft and design practices and technological standards such as robustness, durability and reproducibility are then challenged through the unworkable artefacts.

The Patroniser and *Vinip* partially exploit the mechanism of paradox. In this case, the work targets common design principles introducing the idea of uncomfortable interactions. Tangible artefacts might then be re-evaluated through this lens, and such offbeat statement might help to build awareness about the current ubiquitous technologies that already put us in an "uncomfortable situation".

The Winner instead might use paradox in regards to the expectations we have towards technological novelty. While tinkering with arcade game aesthetics and their seductive powers, the designer breaks norms and expectations by building an overly complicated game which is impossible not to win. According to the maker: *"as a kid, you know, you want the toy and you want to play the game ... but it doesn't matter how much money you put on it ... it's rigged!"*. We might say the paradox of a technology that compulsively generates both always-new desires and the illusion of satisfying them.

We discovered that paradox has been exploited by our participants to elaborate on technology and its socio-cultural implications. Overall these works offer critiques of methodological alignments and standardisation of thinking, a discussion we also find in HCI contexts [27].

Hyperbole

Hyperbole - the exaggeration of ideas to intensify feelings or impressions - is a rhetorical device that has often been used in those works concerned with musical issues. In particular, the messages disclosed using this type of absurdity relate to the embodied intimacy musicians develop with their instruments [372, 261] and the design, evaluation and marketing of new accessible musical interfaces [262], both of which are lively debates within the domain of music interactions. Two examples are *Pipe Technology* and *Anyone can Make Music*.

In *Pipe Technology* the scale of standard digital instruments are massively expanded. A slider potentiometer then becomes 1 meter long. While sharing their reflections on this absurd magnification the artists explained: *"there is connection between precision in small things and large things. So if you have a very small knob to move around, you can never be really precise, even if you barely touch it you could already have moved it. The super large thing actually require some effort before you can move it from one position to the other. It will be more physical.. ... We are exploring how that influences our experience of playing"*.

Exaggeration then becomes a means to open up new design spaces and look at a specific music technology issue in a different way. Thanks to this silly ambi-

tion, which is allowed by a lightweight context, it is possible to explore full-body interactions with large-scale controllers escaping technological trends.

Anyone can Make Music instead aims to amplify the alleged musical opportunities offered by many commercially available digital instruments which (over-)simplify music making. The implied discourse might relate to the commodification of creativity and learning processes. In particular, since these processes are characterised by a complex, time-consuming and effortful course, we might take advantage of "expert systems" which "can pull out expertise that take tens of thousands of hours for humans to learn ... this means that everyone has access to this type of expertise" [2]. On one hand an appealing product, on the other the perspective of a very naive idea of music practice and creativity.

Suspension

Suspension (or aposiopesis) is a figure of speech that might be helpful to describe a kind of absurdity we observed in some of the impractical artefacts. This rhetorical figure refers to a "sentence that is deliberately broken off and left unfinished, the ending to be supplied by the imagination, giving an impression of unwillingness or inability to continue" [216, p. 20].

One of the pieces that particularly relates to this concept is *Dancing with Jelly*. While interviewed, the artist that developed the piece explained: *"In Tai chi there is this idea of 'non-doing' ... I mean, even silence is generative. ... at the beginning of the hackathon someone mentioned that the more you can control an instrument the more you can express through it ... I am more interested in non-expressing ... maybe the less you can control, the more you can express ... I don't think anybody knows what do they actually want to express"*.

This intentional suspension is in contradiction with many functional approaches to the use of art technology (i.e. as a means to express something). From our viewpoint, this piece therefore seeks to stretch conventions on body expression through the idea of non-doing. *"It's not about creating a symphony, but what's happening when you are not trying to create a symphony? Maybe your symphony appears anyway"*. The notion of 'playing for' is than replaced with the concept of 'playing with': *"allowing the unpredictability to come out of the system"*. These kinds of observations echo the debates around contemporary art practices which aims to acknowledge a diversity of aesthetic goals in virtue of the "complex interrelation of human and non-human agents" [156].

2 Matt Wood announcing DeepComposer - last access April 14, 2023.

Pompom Swatches can also be interpreted as a conscious act of suspension. In this case, the piece might represent a sort of resistance (or reticence) towards hi-fi and forefront technology. Indeed, the tools and materials used in this project belong to hand-craft practices and, in contrast to futuristic machinery procedures, they look to ancient techniques and methods. We correlate these attitudes to craftivism approaches in which "domestic arts" such as yarn-bombing or cross-stitch are used to engage with critical discourse on social process of collective empowerment art expression [150].

Oxymoron

We noticed that some of the hackathon's projects rely on the combination of the opposites. *MusiTex* is an example of this contradiction in terms: a set of musical instruments in which sound is replaced by text. In our view, *MusiTex* proposes a playful critique that mitigates "the emergence of seemingly omnipotent computer music languages and ultra-specialised music apps" [236]. In short, as suggested by other artefacts, the message might be that latest cutting-edge technologies do not guarantee convincing musical results (as in the surreal non-musical output of *MusiTex*). In fact, the controversies related to the success or failure of new music technologies is a hot topic in the NIME research community [268].

MIDI Uncontroller is another example of musical oxymoron. According to the creator: *"a lot of the stress in making music is about what is going to be the next note, or how you should play ... so why don't let machines make choices for you?"*. However, this particular machine is designed to take away from the performer way too much control. The musician ends up being completely excluded from the performance. An uncontrollable keyboard points at the anxiety and frustration many musicians feel towards what the designer calls *"happy accidents"*. The instrument's contradiction then relates to a long-lasting debate on mistakes in music performance [46]. We found that the device of self-contradiction was mainly to investigate music technology and performance. These artefacts raise questions on the long-term impact artificial agencies will have on our understanding of perception of musical instruments [161].

5.3 10.000 INSTRUMENTS WORKSHOP

The 10.000 Instruments workshop took place during NIME 2020 in the form of an online gathering during which conference attendees could collaborate to sketch

new interface ideas. We introduced the activity as a playful, permissive and lighthearted event concerned with the creation of seriously silly concepts, not-yet-existing designs and absurd variations of existing instruments. Although the workshop has been originally conceived as an hands-on group activity to be held at the Royal Birmingham Conservatoire, due to the COVID-19 pandemic and the online migration of the conference, we adapted our plans in order to accommodate the new event format. The workshop has been presented to the NIME 2020 participants as follows:

> *"The 10.000 Instruments workshop aims to cheer up social distancing through some playful interactions. We invite the NIME community to dive in an online gathering to collaboratively sketch as many instrument ideas as possible. A lighthearted activity that might ease for a couple of hours the challenging situations we are all experiencing. An opportunity to experiment with alternative ways to generate interface ideas and speculate on music tech through open-ended artefacts and playful design explorations. An unconventional workshop to advance the debate around the complex, interdisciplinary and multifaceted nature of contemporary musical instruments"* [3].

Based on the outcomes of the previous absurd hackathon, we developed the activity to facilitate critical discourses around NIME practices and trends. However, in view of the conference virtual venue and modalities, we quickly decided to emphasise the creative and cheerful elements of the activity. Our ambition was then to propose a pleasant and entertaining workshop which could also provide some further hints to investigate absurd making in music technology contexts. Specifically, we focused on two of the questions articulated in the original proposal: *"how can the exploration of make-believe, fragile and contradictory artefacts convey future visions beyond the paradigms imposed by current music tools? And, how can we question the role of technology through creative and playful perspectives?"* [4] Nevertheless, we were also aware that the workshop outcomes would not necessary answer the questions sketched in our proposal, but rather leave space for open-ended discussions and creations, and, possibly, pose new questions related to critical and personal approaches to NIME practices.

3 See the NIME 2020 workshop webpage – last access April 14, 2023.
4 See the accepted workshop proposal – last access April 14, 2023.

5.3.1 *Workshop facilitation*

Once the workshop was accepted, we opened the subscription to the conference attendees, setting a limit to a maximum number of 30 participants. Similarly to the absurd hackathon, interested participants were invited to send an idea for an impractical and not-yet-existing musical design. These ideas have been used to feed a random generator of absurd instruments [5] to be (ab)used during the workshop as a source of inspiration. The activity was then introduced to the signed-in participants as an online collaborative workshop with the aim to sketch as many instrument ideas as possible over the course of two hours.

We decided to use Google Slides as a shared workspace for collecting and developing the instrument ideas. We invited participants to create absurd instruments using any means they felt comfortable with, as far as the results could be documented and shared online - including (but not limited to) searching, copying and pasting images or hyperlinks from the internet, 2D and 3D rendering, mock-ups, collages, pictures, describing the idea with some text or simply drawing it on a piece of paper – see Figure 5.12. We encouraged participants to gather in advance some random bits of recycled and found objects from around their home to be used during the workshop. We also provided a suggestion of mundane tools and materials participants might use to build instruments mock-ups [6].

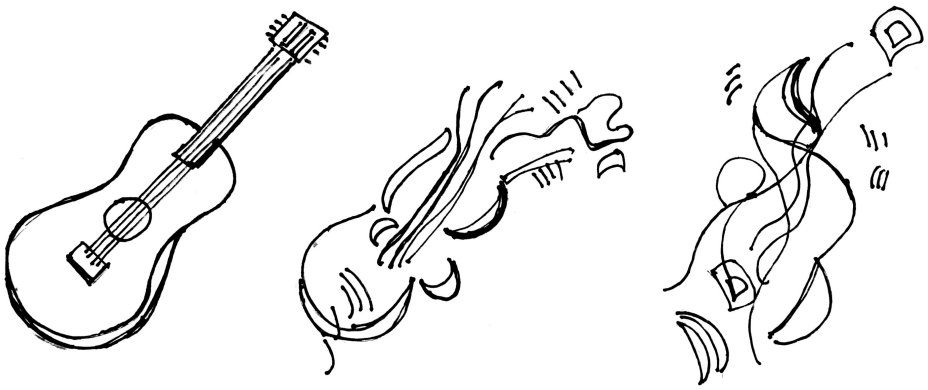


Figure 5.12: An image used in the workshop webpage to inspire the creation of abstract musical artefacts.

In the first slides of the shared Google document, we outlined a draft of the workshop structure. We arranged the schedule based on the design fiction inves-

5 See the random generator of absurd instruments designed by Pete Bennet, one the of the workshop organisers – last access April 14, 2023.

6 See the 10.000 Instruments workshop webpage – last access April 14, 2023.

tigations introduced in Chapter 3, where practical and fast-paced tasks are introduced to urge creative making and sidestep insecurity and overthinking. We therefore organised the activity based on the following steps:

- **Step 1** (10 min) – *Welcome* – intro from organisers;
- **Step 2** (20 min) – *Solo crafting* – participants are invited to find inspiring materials and objects around the home, craft an instrument idea, document the results and upload the idea on a slide;
- **Step 3** (20 min) – *Collective sprint I* – attendees are encouraged to explore others' ideas, get inspired and start collaborations to further create;
- **Step 4** (10 min) – *Optional coffee & group reflection* – a quick pause in making to rest and refresh, but also to give participants the opportunity to exchange on the making processes – e.g. sharing techniques or ask questions to the group for the ideation of new instruments;
- **Step 5** (45 min) – *Collective sprint II* – during this longer phase attendees are encouraged to expand absurdity by making variations of existing concepts (and possibly introduce new questionable ideas) to reach the impossible target of 10,000 instruments;
- **Step 6** (15 min) – *Finale* – a conclusive step to thanks participants and invite them to share their reflection on the workshop process and outcomes.

In the same introductory slides we also included a set of guidelines for the use of the online workspace, see Figure 5.13. In particular, we were concerned that participants would modify or delete the work of others. We therefore suggested to place a new idea in a new slide, and insert concept variations next to each others so to generate "linear taxonomies" of absurdities. We also encouraged participants to consider whether the uploaded contents might be inappropriate for other attendees, and we suggested a set of key words to provide some more specific cues on the kind of permissive and open-ended approach we envisioned for the workshop.

In order to let participants familiarise with the workshop tools and modalities we shared the Google doc a few days before the event, including the two slides for the activity guidelines and structure. In order to facilitate and inspire participants, we also designed a slide template to be filled with contents (Figure 5.14) and a few examples of absurd instruments – amongst others, the *Nothingizer* and the *Slow Growth Piano* in Figure 5.15. Finally, we informed participants about our intention to make public the workshop outcomes (i.e. the shared online document) as a

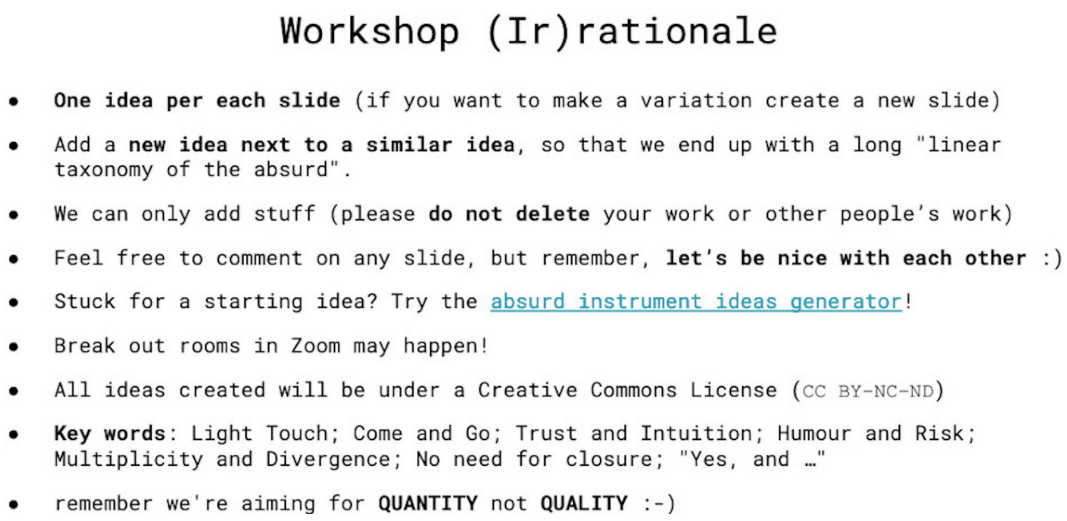


Figure 5.13: The workshop guidelines slide inserted at the beginning of the shared Google workspace.

roughly organised collection of instrument ideas and conversations emerged during the event [7]. This collection of sketches and annotations as well as the workshop call and methodology would then be available resources which might stimulate future debates around unconventional NIME methods and their expected outcomes.

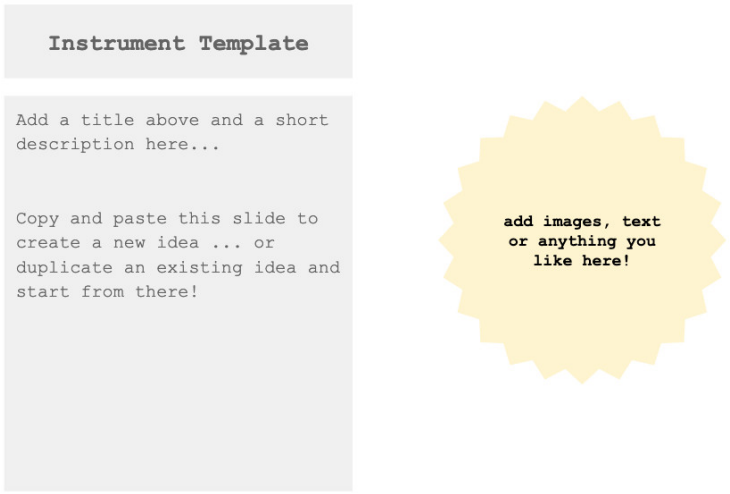


Figure 5.14: Slide template provided to participants.

7 See this document to review all the absurd ideas created during the workshop – last access April 14, 2023.

Slow Growth Piano

An instrument for your garden, this specially adapted upright piano allows you to grow plants that over time will press the keys and create slow, long-form generative pieces.

Your job as gardener is to cultivate chord formations through careful topiary. Pre-seeded to play "Daisy Bell (A Bicycle Built for Two)" over the course of 15yrs.

Nothingizer

Be in full control of the most powerful and efficient music gear ever designed.

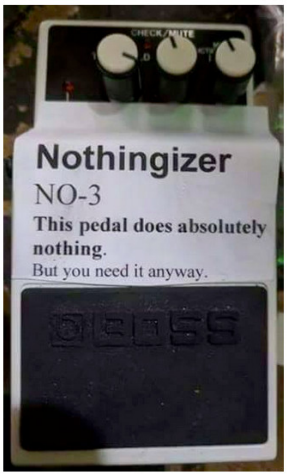


Figure 5.15: Examples of absurd instruments presented by the workshop organisers to inspire participants.

5.3.2 *A solid 3%*

Attendees of the NIME 2020 responded enthusiastically to the workshop call (i.e. fully booked event), suggesting a desire to contribute to and participate in the kind of exchanges elicited by our absurd activity. Overall, during the two hours participants fervently created over 300 questionable musical ideas and absurd instruments – as gladly noticed by one of the organisers: "a solid 3%".

Besides presenting a selection of design concepts generated during the workshop, this section examines some of the features that characterised the work of our participants. The speculative instruments are then grouped and discussed based on the following themes:

- Visionary and critical statements
- Making the familiar strange
- Absurd variations
- Improbable collages

Visionary and Critical Statements

The design concepts uploaded touched upon a great variety of techno-musical issues. Moreover, the speculative artefacts proposed by our participants are sometimes difficult to interpret due to their controversial, open-ended and subjective connotations. In what follows, we present a selection of improbable musical ideas to provide an overview of the diversity of outcomes produced during the activity.

Many of the design concepts proposed by participants unlock clever techno-musical visions which we might experience in the next future. Examples of such unrealistic yet captivating concepts are the *Personal Stylus* and embodied turntable stylus which translate surfaces into sound (see Figure 5.16) and the *PCB Prodder*: *"the next step in circuit bending synths ... a type of test/gauge tool that can poke around old and dead PCBs to find interesting electrical routes and modulation."*.

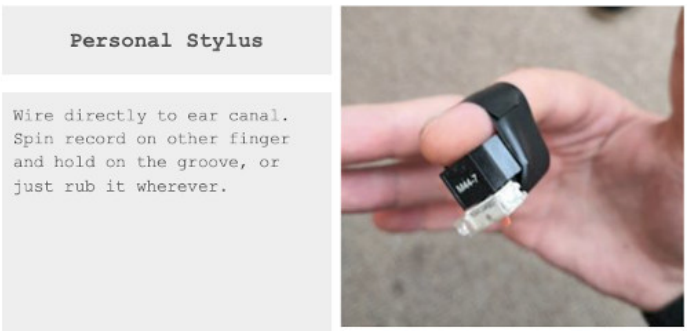


Figure 5.16: A bio-mechanical and embodied interface based on a turntable stylus.

In line with the attitudes we often found in the absurd hackathon, some of the instruments proposed during the workshop exploit irony to critique NIME research *clichéd* and commonplaces. As an example, participants would often place an image of a piezo transducers connected to a knob on the top of any instrument ideas, so to create the "augmented" version of that given artefact (see some of the examples provided below).

The *Laptop Ensemble* shown in Figure 5.17 makes fun of the laptop orchestras we often found in music technology institutions through the idea of making music using only the default operating system sounds of our machines. Another critical ap-

Laptop Ensemble

Default OS sounds are left on, and a group of performers use the computers to go about their regular business, leading to alert prompts, start up sounds, notifications, the sound effects of various applications and so on.

Ideally the ensemble would use a variety of operating systems from different points in history.

Figure 5.17: A laptop orchestra which performs notification sounds only.

proach found in our absurd catalogue looks at existing music technology devices considering the specific aesthetics they promote – e.g. *LightOperaTribe* a sequencer specifically designed for the production of "crap" opera music (Figure 5.18).

LightOperaTribe

In recognition of the fact that many beat based hardware boxes make it impossible for you to make anything other than crap dance music….

We present the LightOperaTribe which only generates crap light opera with adjustable racism, cultural imperialism and bourgeois smugness for the automated libretto generator.

Figure 5.18: The *LightOperaTribe* hardware: a direct critique of the musical aesthetics inscribed in and mediated by many sequencer devices.

Some participants instead targeted nominal NIME research concepts to provoke playful reflections on the impact they had throughout the years. This is the case of the of *Crumple Brahms*, a mockery of *composed instrument* concept [318] where *"the composition is the instrument"*; and the *HyperMetaCyberInstrument*: *"the only instrument you will ever need"*, which winks to John Bowers' and his *Infra-Instruments*

notion [70] – see Figure 5.19.

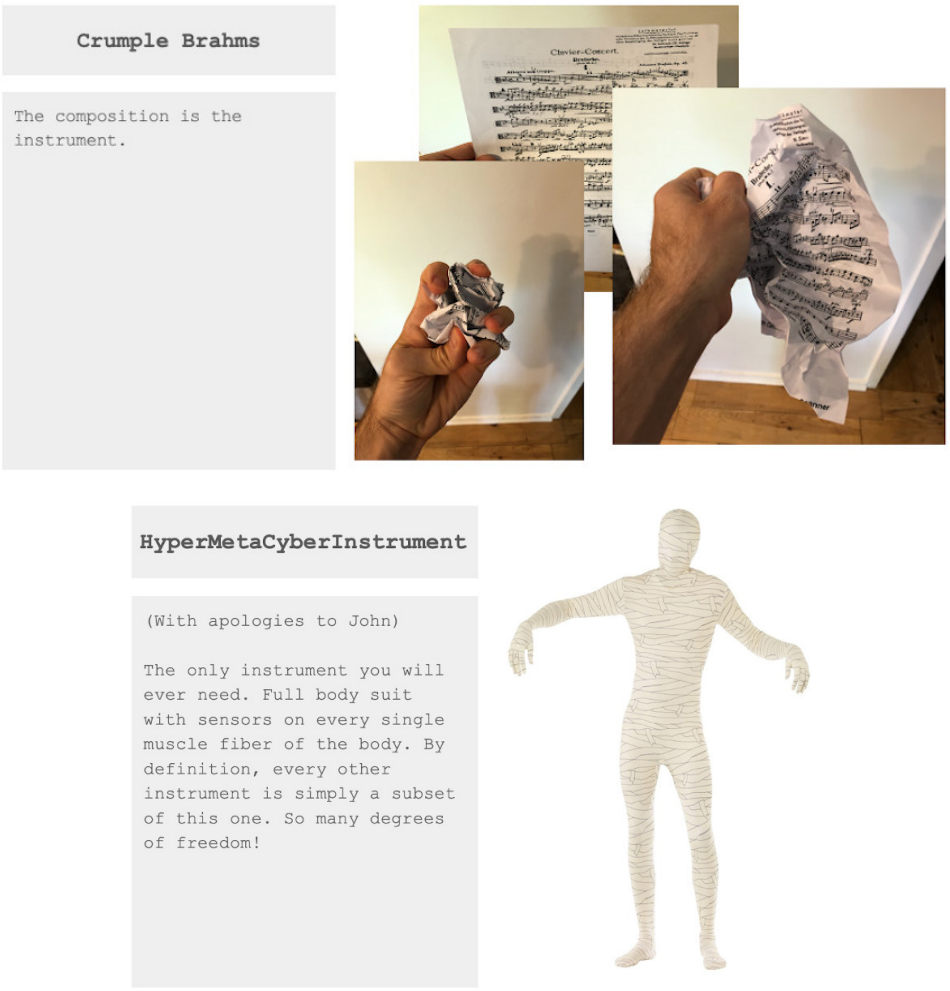


Figure 5.19: Examples of absurd musical designs making fun of well-known NIME research ideas.

Making the familiar strange

While reviewing the impractical ideas collected, we noticed that participants often used personal and domestic objects, which are rendered unfamiliar and extraordinary to convey absurd musical visions. Many of the questionable instruments developed during the workshop are based on highly personal items which are part of the domestic and everyday experience. For instance, participants often proposed impractical concepts using household objects and tools like stationery, kitchen utensils and furniture. The *Lockdown Organ* is a brilliant example of such approach, where toilet roll tubes are recycled to build an instrument for pandemic

times. Similarly, artefacts like *DIY data sock* and *Melodiyoga* provide a good sense of the mundane and domestic qualities that characterise many of the workshop absurd designs – see Figure 5.20. *Tone Cube* and *Lego Circuits* instead show how common toys were often used by attendees to suggest original and amusing interface ideas – see Figure 5.21.

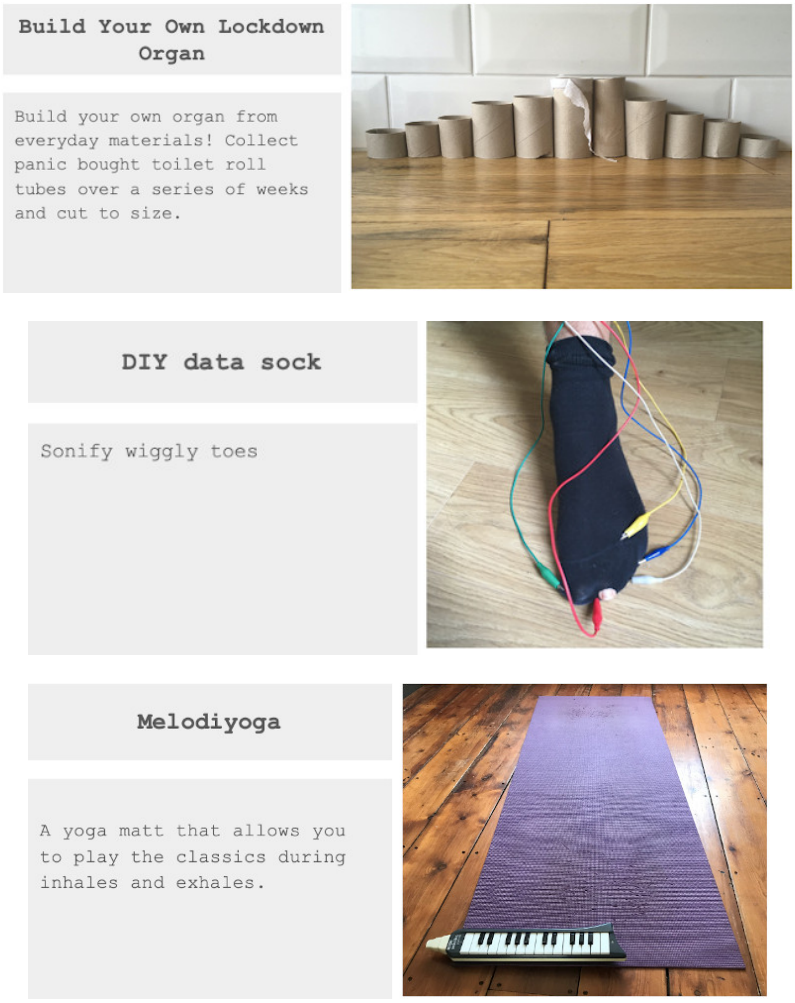


Figure 5.20: Examples of absurd concepts based on domestic and everyday objects.

These examples illustrate how, in the context of our workshop, familiar and personal objects suddenly become exceptional and enigmatic. *Making strange* or *defamiliarisation* is a technique often exploited by artists to intensify and broaden the perception of common things. An approach pioneered by Surrealism and Dada movements [11] which Viktor Shklovsky thoroughly describes in his essay *Art as Technique*:

Tone Cube

Each colour is a different note.
Rotate the cube to create different musical sequences.
Can be bowed, plucked, hit or strummed.
When solved and all colours are on the same side a new instrument sound is unlocked!

Lego Circuits

I love building with lego!
What if the lego made noise as you built, played with, or broke your creations?
Introducing Lego Circuits

No one asked for this, but whatever!

Figure 5.21: Examples of absurd concepts based on toys.

> *"The technique of art is to make objects 'unfamiliar,' to make forms difficult, to increase the difficulty and length of perception because the process of perception is an aesthetic end in itself and must be prolonged"* [328, p. 2].

Defamiliarisation can be therefore understood as a device that forces us to (re)consider how we perceive the familiar and the tacit [374]. This process of estrangement is properly captured in the surrealist formula "making the ordinary extra ordinary" [221]. A common defamiliarisation exercise is to ask someone to describe a common object as if they were talking to an alien coming from Mars [36]. Another is to imagine ourselves as extraterrestrial coming from Mars and (mis)interpreting our world while encountering it for the first time. In short, to defamiliarise can be understood as confronting something *with new eyes*, sidestepping the obvious and suggesting alternative perspectives.

Aside from the arts, the practice of making strange has been also exploited in the fields of anthropology and HCI to question how "cultural phenomena gradually come to be seen as natural" [36, p. 152]. While considering the technology for everyday home life, Bell et al. propose defamiliarisation as "a useful tool for creating space for critical reflection and thereby for opening up new possibilities for the design of domestic technologies" [36, p. 150]. Wilde et al. instead explored the "power of estrangement" in the context of embodied design to stimulate ideation

processes and enable designers "to effectively and critically share nuanced and repeatable methods" [374, p. 10].

We would then suggest that our participants used the device of defamiliarisation in order to twist the obvious and provide contradictory viewpoints on both mundane objects and techno-musical assumptions. A creative process that "removes objects from the automatism of perception" [328, p. 3], subverts expectations and stimulates critical reflections. Although these musical insights can be sometimes hard to capture, and turning them into functional design might be at odds with available technology and resources, we can appreciate these outcomes as suspensions of disbelief which convey highly subjective positions embedded in intimate and everyday practices.

Interestingly, we noticed that these concepts were rarely reinterpreted as variations by other participants. A possible explanation of this phenomena is that, as these defamiliarisations greatly depend on intimate and personal relationships amongst participants and their domestic objects, they might not resonate with the sensitivities of the most. A lack of shared ground might make these artefacts more cryptic and less available for reinterpretation.

The musical statements based on familiar and ordinary objects might then be interpreted according to parallel perspectives. On one hand, by making strange of the ordinary, these musical artefacts encourage a deeper reflection on our lived experience - as noted by one of the workshop organisers: *"to see things as they are perceived rather than as they are known or anticipated in advanced"*. On the other hand, these musical designs can be considered as playful opportunities to generate subjective musical visions through the defamiliarisation of personal and everyday objects. Visions that allow participants (and ourselves) to explore inner, alternative and contradictory design spaces [14].

Absurd variations

Not surprisingly, another ideation process we could often recognise relates to the practice of generating variations of illogical and silly concepts. Indeed, since we anticipated its creative potential, while presenting the activity, we mentioned this strategy various times – e.g., in the workshop call and guidelines. The spectrum of topics and thematic ramifications emerged through the many absurd reiterations of already rather silly concepts are vast and difficult to organise in homogeneous groups.

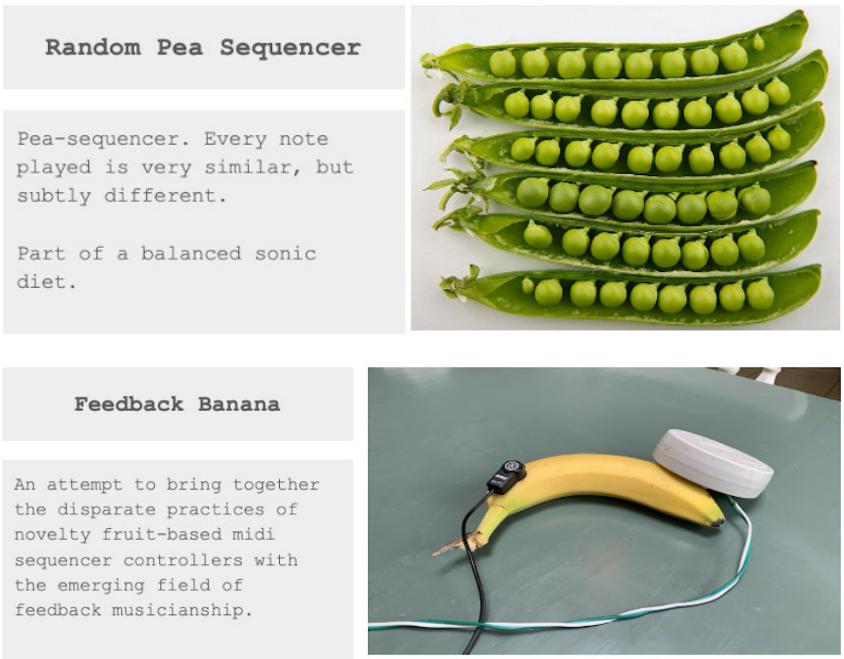


Figure 5.22: Examples of absurd musical designs based on fruit and vegetables.

Figure 5.23: Tuned up Glass Harp.

Examples of impractical interface "genealogies" include instruments based on food and beverage, see Figure 5.22. In this particular area, frequent musical puns were alcohol based instruments such as the *Tuned up Glass Harp* (Figure 5.23), and the *Breathalyser Saxophone* which only plays sounds if alcohol is detected in the breath of the performer.

Particularly frequent were series of instruments based on vegetals and animals, including plants that are genetically modified to produce sounds when bowed or

plucked or cat-based instruments – see for instance the *Catpipe* and the *Bowed Cat* – see Figure 5.24.

Figure 5.24: Example of a feline absurd music interface.

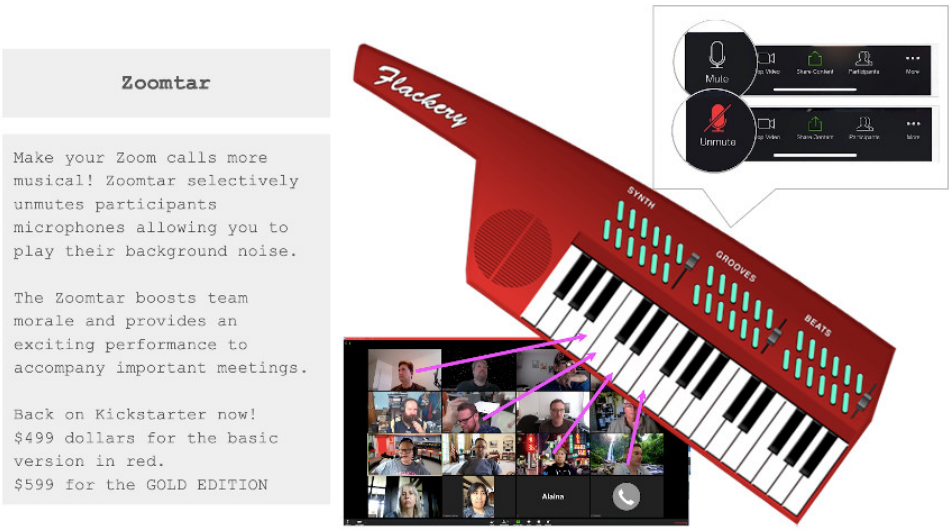
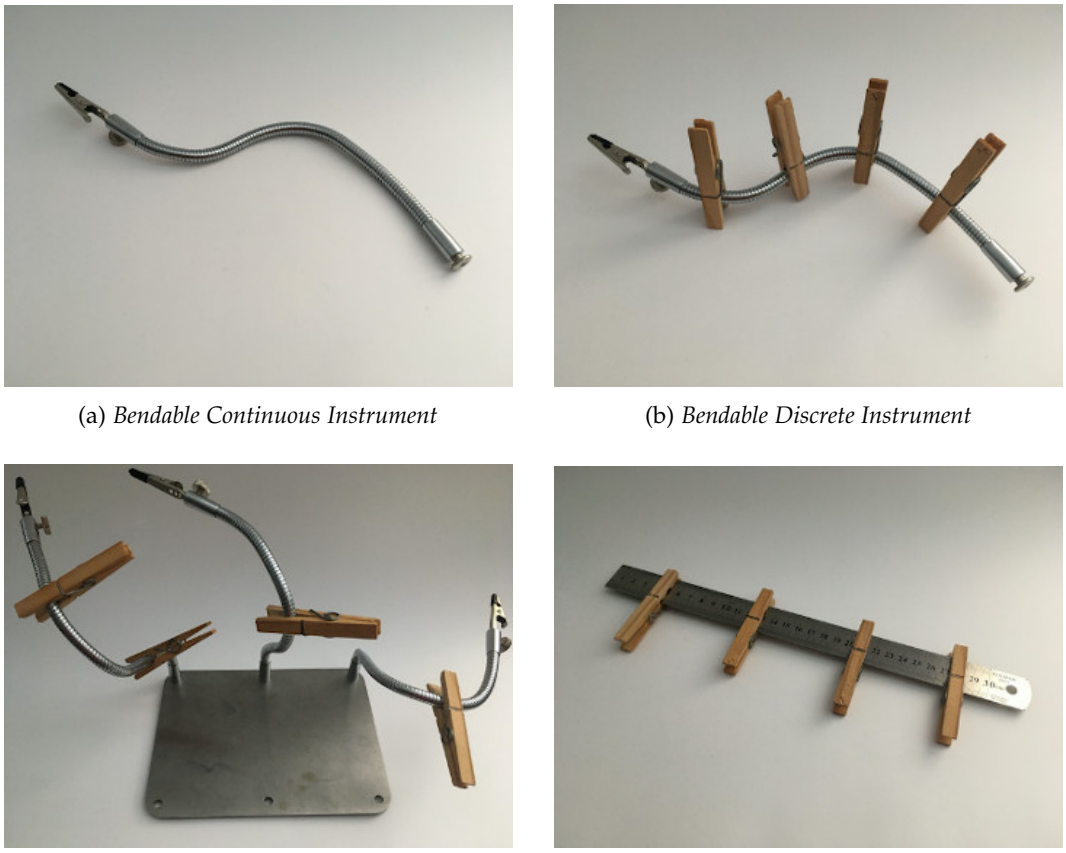


Figure 5.25: A music interface concept based on the Zoom platform.

Participants also proposed various musical designs inspired by the ways the pandemic modified human communication. These comprise the *Corona Mask Breath Amp*, which amplifies the *"muffled murmurs present in current communication"* by placing two Kazoos on a mask at the nostrils level. The *Zoomtar* instead makes Zoom calls more musical by providing *"an exciting performance to accompany important meetings"* (see Figure 5.25). Specifically conceived for our workshop, the *10.000 Instrument Squared* is a device that *"analyses zoom calls and uses advanced deep learning to synthesise the sounds that would be made by any absurd musical instruments*

mentioned".

Out of the many taxonomies of absurd instruments proposed by participants we identified a particularly interesting sub-group of concepts characterised by minimal and open-ended design features. These abstract ideas – often presented only with a title and very little or no description – include the *Bendable Continuous Instrument* which, amongst others variations, evolved into the *Polyphonic Bendable Discrete Instrument* and the *Not Bendable Discrete Instrument* (see Figure 5.26).



(a) *Bendable Continuous Instrument*

(b) *Bendable Discrete Instrument*

(c) *Polyphonic Bendable Discrete Instrument*

(d) *Not Bendable Discrete Instrument*

Figure 5.26: Some examples of minimal and undetermined design variations.

Another example of rather *cryptic* musical artefact is linked to the *Black Box* instrument, a concept which first appeared with the description "I am not sure what it does". Such intriguing and open-ended artefacts stimulated the imagination of our participants. Iterations of the *Black Box* instrument include *The Frankencode Black Box* which *"takes all your old crappy, poorly implemented code snippets, normalizes inputs and outputs and turns it all into beautiful music"* and *The Ultimate NIME*:

a *"permanently sealed"* box that *"contains the ultimate NIME - an interface perfectly balancing a moderate learning curve with quick pay-offs and superior user satisfaction"*. Ultimately, *The Ultimate NIME* became the *The Augmented Ultimate NIME*, as augmentation was achieved by placing a piezo on the top of the box Figure 5.27.

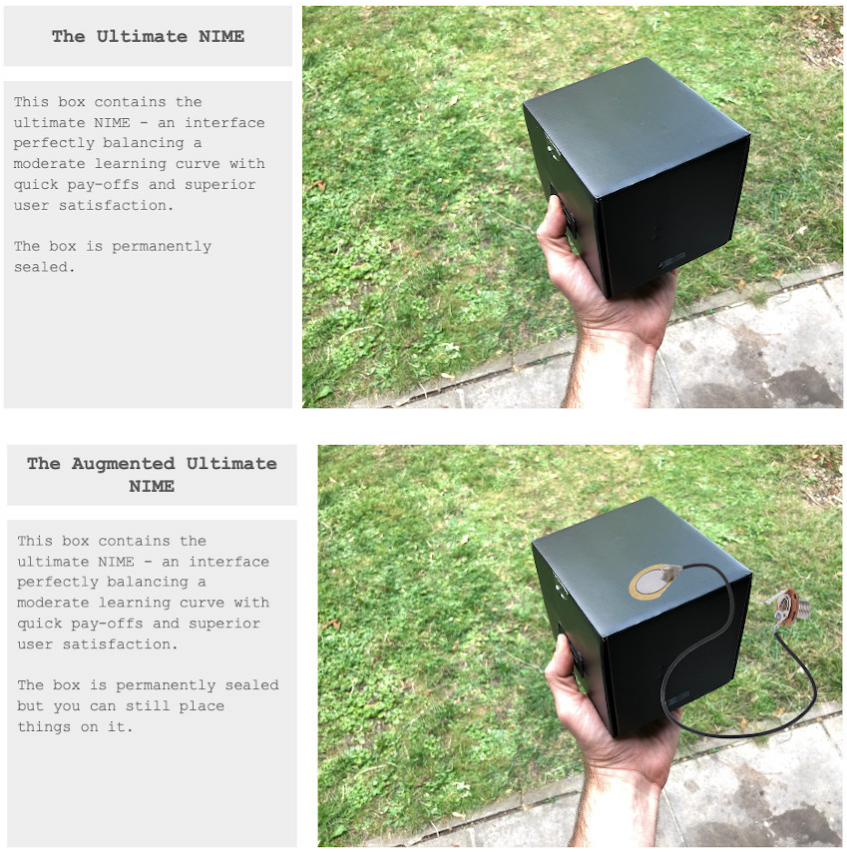


Figure 5.27: Some variations of the *Black Box* instrument.

Overall, we could appreciate how the "variation mechanism" often functioned as incentive for the ideation of absurd interfaces. While creating new variations, participants were able to develop a broad range of statements around different music technology topics and artefacts by responding to the absurd ideas and comments presented by their fellows. An example of such reiterative device is shown in Figure 5.28 where it is possible to appreciate the complete set of alterations which began with the silly idea of the *Hammer* instrument. The *Hammer* alterations illustrate how participants used to grab and edit low quality images (e.g. from the internet) to retrieve multiple times the same questionable concept in rapid fashion. Alternatively to this approach, occasionally attendees introduced new absurd meanings by simply adapting the artefact description.

(a) **Just Hammers** – *"Hammers turn anything into a percussive instrument"*

(b) **Hammer in music** – *"Hammer in the music that you like"*

(c) **Bag of Hammers** – *"A bag of bags of hammers (a smart musical instrument)"*

(d) **Bag of Hammers with Anvil** – *"Just in case"*

(e) **Augmented Hammer** – *"Augmented instrument to augment your possibilities"*

(f) **Virtual Hammer** – *"VR Musical Instrument"*

(g) **MC Hammer** – *"A microphone designed to be hit with a hammer. Developed to accompany the use of the DJ hammer, a form of turnatablism based around the heavy use of hammers. Perfect for synthesising the post MIC DROP "MIC DROP" sound"*

(h) **Smart MC Hammer** – *"Perfect for synthesising the post MIC DROP "MIC DROP" sound and connected material"*

(i) **Tuned Nails** – *"Each nail is a different length and tuned to a different note. A common use is with the MC Hammer"*

Figure 5.28: Nine variations on a silly musical instrument.

In line with the spirit of the event, exchanges and variations usually occurred in a rather disorganised and discontinuous fashion. Participants started to reiterate absurd ideas since the third phase of the workshop, and continued, freely jumping from one absurd artefact to another, until the end of the event. On this note, we observed that only a few verbal exchanges occurred during the workshop (via Zoom videochat) and participants primarily focused on the "practical" task of creating musical absurdities without coordinating with each others. Overall, we would argue that these messy iterations and permissive transitions can be considered as an essential element of our activity, which enabled a great diversity of outcomes.

Improbable collages

Another recurrent strategy for the creation of questionable instruments relates to the use of pre-existing images, including – but not limited to – retrieved illustrations and pictures from the internet. Pre-existing images are then fetched (e.g. retrieved from the internet), de-contextualised and re-combined in unreasonable ways. Furthermore, participants often exploited the absurd collage technique to generate variations of the interface concepts proposed.

During the workshop participants would often edit and rapidly combine different images to generate questionable and amusing musical instruments. Examples of such image compositions are the *Flying Horn* – an impractical technique to play horn instruments, the *Plopper* – a very silly sound design tools, and *The Shit Factorty* – an algorithm for the generation of music inspired by the latest pop/-mainstream aesthetics (see Figure 5.29).

Since the pioneering work of artists such as Braque, Picasso and Schwitters the influence of the collage technique (as assemblage of found objects) can be found in every major art movement of the twentieth century – including the work of the Dadaists in the 1920s, the *detoumement* approach adopted by the situationists, the 1960s pop art and the appropriation art of the 1990s [364, 109]. In the context of our workshop, attendees exploited the collage technique to juxtapose images coming from very different contexts to either critique existing music technology practices or create novel and contradictory musical artefacts.

The collages created are made with images of everyday objects and tools, popular culture references as well as snapshots of music technology artefacts. These assemblages are often based on the loose combination of "found" low quality pictures. Far from being refined design illustrations, these instruments therefore emphasise the value of the concept and ideation process over the hypotetical *final*

Plopper

Drop rocks in a bucket of water. Plop!

This technique can also be use don the Chudaphone.

FLYING HORN

Pulled at high speeds and high altitudes this large horn is weighted to balance

Multiple horns allows for polyphony

The Shit Factory

Algorithmically generated pop music sonifies stool health.

From poop to pop!

Fully integrated with the Bristol Stool Chart and the US Hot 100.

(Of course, as an occasional bass player, I would lower the tone.)

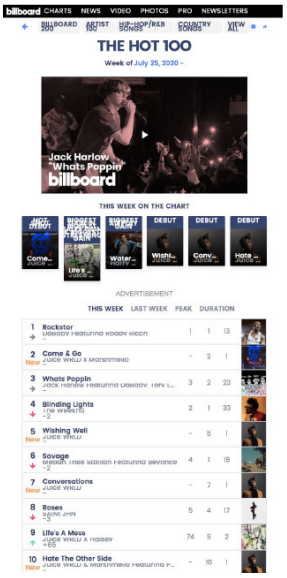


Figure 5.29: Examples of artefacts featuring pre-existing images and improbable collages.

product. Participants also exploited the collage technique to iterate concepts previously introduced by other attendees. See for instance the *Frankencode Black Box* (a variation of the *Black Box* instrument) with screenshots of different audio programming languages, and the *LRADs* instruments which propose alternative designs of the LRAD weapon (Long Range Acoustic Device) – Figure 5.30.

The many collages proposed by participants revealed the generative power of such technique. The handy and rapid process of reiterating found and decontextualised images then served as a compelling device to further develop others' ideas. An approach that gave attendees opportunity to follow playful and silly intuitions, and possibly explore challenging and risky concepts through humour and absurdity.

5.4 DISCUSSION

The playful but serious approaches explored in our research allowed us to engage with rich, complex and amusing design outcomes. Clearly our strategies are not meant to produce either quantifiable evidence or "silver bullet" technology-driven solutions [55]. However, they turned out to be rather powerful tools to made visible personal design knowledge, share critical visions and reason about human-machine agencies and ends. Furthermore, the process of making, sharing and reiterating questionable instrument ideas then served as a compelling stimulus for music technology practitioners, which had the possibility to follow playful and silly intuitions and possibly explore highly personal concepts through the creation of design dissonances and musical obstructions.

5.4.1 *The discovery of contradictions*

The main idea behind our research is that through the combination of play and making it is possible to create reflections that would be difficult to elicit with more traditional methods, while avoiding overly theoretical and formal discussions. Playfulness, humour and irony are then crucial elements exploited by our participants to inspire making and inscribe subjective meanings into musical objects. Andrew Hugill suggests that:

> *"humour lies in seeing an incongruity between a fact and an imitation of a fact ... the incongruity observed is not complete, but only partial; because a likeness as well as an unlikeness must exist in the bogus ... the mind half accepts, half*

Figure 5.30: Variations of questionable audio tools made out of image collages.

rejects what is being offered to it for recognition ... it becomes simultaneously aware of its own madness and its own sanity" [187, p. 14].

Considered as one of the most evolved defence mechanisms [101], humour therefore explores the absurdity potentially inherent in any event, through the juxtaposition of incongruous elements [73]. Interestingly, the etymology of absurd (*ab* - "off, away from" + *surdus* "dull, deaf, mute") relates to expressions such as *out of tune*, *discordant* and *dissonant*. Based on the insights gained throughout our research,

we frame absurd making as a critical and creative practice for the discovery of contradictions. Contradictions might help to unpack individuals' values, stretch conventions and question norms and expectations linked to current and future technology.

While reflecting on the projects developed during the absurd hackathon we were able to identify four type of contradictions: paradox, hyperbole, suspension and oxymoron. These rhetorical dissonances functioned as a conceptual guide to illustrate new interface ideas, personal statements and alternative visions.

During the hackathon participants proposed many original and inspiring musical artefacts, nonetheless many of the projects created convey implicit criticisms towards existing technology. Indeed, one of the lessons we learned is that contradictory and absurd making can be convenient devices to point out bad design ideas and uncover poor implementations as well as arguments why sometimes it is better to not design technology at all [35, 313].

In the context of the 10.000 instruments workshop, we instead found that participants often presented musical artefacts which confound everyday expectations. They do so by making strange of domestic objects and proposing unfamiliar design concepts which challenge and hinder the perception of habitual things. The process of defamiliarisation was then exploited to create musical obstructions which, by introducing estranging and unexpected design ideas, allow us to (re)discover the unconscious assumptions we normally don't see [374]. Furthermore, contradictions were created through the composition of illogical collages, where dissonant images were often juxtaposed to envision and evolve absurd instruments.

Thanks to our research we realised the the potential of design contradictions to appreciate highly individual musical visions. This differentiation in outcomes may constitute the central value of the approach considered in this chapter. The design statements proposed by participants include sharp music technology critiques, personal reflections on everyday musical practices as well as naive, uncooked and obstructing speculations. Overall, each techno-musical (pro)position described in this chapter can be considered as an "opportunity to arrive at more complex understandings" on subjects that often "are either too difficult, or too banal, to be addressed by the traditional design brief" [14, p. 112].

The permissive approach adopted as another essential element of our research. This attitude allowed participants to follow playful and silly intuitions, challenge others' ideas and explore ambiguous visions through humour and absurdity. This

open-ended process of making, sharing and reiterating questionable instruments then served as a generative stimulus which would sometime produced equivocal and even cryptic outcomes. In line with Gaver et al.'s notion of "ambiguity as a resource for design" [141], we would argue that the openness and multiplicity of processes and outcomes characterising our absurd activities offered a compelling framework to highlight personal and creative insights and potentially generate awareness through critical reflections.

On the other hand, we are left with many questions that still need to be addressed. As one of the hackathon participants observed: *"It's difficult to be absurd"*. Future work should better tackle how to facilitate and challenge absurd making in terms of format, activities, materials, and mentorship. For instance, in the case of the hackathon, we realised that more time could have been dedicated to the performance of the musical tools designed. Performance (in a broad sense, i.e. interacting with artefacts and people) might be a valuable place where impromptu and unscripted absurdity might emerge. Absurd making might also be applied to other design methods and communities. In particular, absurd making might be further explored in participatory design contexts for engaging participants and clearly revealing their assumptions and needs.

5.4.2 *Context-specific ingredients*

In this section we consider a set of context-specific elements that shaped the two events reported in the chapter. While reflecting on the events we could indeed identify different factors that particularly influenced design processes and outcomes.

The choice of framing our event as "absurd hackathon" was partially satirical: a critique of rather unsustainable and technology-driven sprint-like events. According to this attitude, we decided to not present the event as a competition (with judges and prizes) and we instead promoted a playful and permissive mood. Our invitation to collaborate for the achievement of a clearly impossible target (i.e. 10.000 instruments in two hours) effectively helped to engage participants and introduce an open and ironical attitude.

Collaborations and dialogues turned out to be crucial in both event, and we were surprised by the many interactions and mutual influences that happened amongst participants. During the online workshop, exchanges happened mainly through the constant development of the absurd ideas. Indeed, we would argue that the absurd variation device, with its inherent iterative and turn-taking mech-

anism, gave participants a fairly equal opportunity to partake – especially if compared to the limitations in verbal contributions of a virtual meeting with more than thirty people. When asked, hackathon attendees identified the initial brainstorming session as a particularly generative stage. They often referred to these early discussion as engaging and useful for getting to know the other participants and start collaborations. Conversations helped to reinforce early ideas, stimulate new concepts and inspire future projects.

In both events we asked participants to submit a proposal of an absurd musical interface. Despite being fully-booked, we received very few ideas from the workshop participants (the submission was not mandatory) and only one participant added in the shared workspace the idea sent in advance. At the beginning of the hackathon we encouraged participants to use submitted proposals as the basis for the discussion and brainstorming session that occurred during the first day. However, in the hackathon call we made clear that selected candidates would have been able to either develop the submitted projects or collaboratively work on a fresh silly idea. Almost half of the makers focused on the creation of the unworkable ideas they sketched in their applications. Attendees that submitted an idea as a group, mainly worked with the colleagues involved in the ideation of the original application. The other half instead ended up doing very different projects. Interestingly, these participants often worked on multiple concepts, collaborating simultaneously with each other in a dynamic and open-ended fashion.

To a certain extent, the playful and non-competitive atmosphere that characterised our events surely encouraged exchanges between participants. However, besides fostering different forms of collaborations, the social dynamics of our events sustained the practice of imagining and building absurd musical artefacts in different remarkable ways. Drawing on the relational theories introduced in Section 2.3.1, group interactions both inspired and legitimised the non-sense efforts of participants. The act of "performing for each other" indeed strengthened musicians to develop and share absurd invents. As safe and self-contained group games our activities somehow established a separate space in which ordinary laws were suspended. This social play somehow produced a shared "second reality" in which participants' initiatives could freely evolve. In this scenario, the stimuli coming from the work of others often functioned as a trigger for people's imagination, provoking further individual contributions – see for instance the absurd variations mechanism of the 10.000 Instruments workshop.

The tools and materials we provided clearly influenced our participants – see the findings and considerations introduced in Chapter 4. A review of the absurd instruments developed during the hackathon revealed that Bela and e-textile materials were used in the majority of the projects: 11 of 18 interfaces featured e-textile materials and 12 artefacts were running Bela. The proliferation of these tools led to the implementations of particular interactions, for instance based on the sensing of non-rigid materials allowing for gestures such as stretch and squeeze [351]. Notably, during the first day of the hackathon, we delivered two short workshops on these tools and the techniques and examples provided in these introductory sections partially influenced the work of participants.

On the other hand, hackathon participants were encouraged to bring their own materials and tools. We noticed that participants shared materials they brought in a spontaneous and cheerful fashion. Some of the items, due to their captivating and absurd qualities, went almost viral and therefore used in many questionable artefacts (e.g. pool noodles). Occasionally cooperation emerged because of a shared interest in the same material or technique. An example of this kind of "collaboration through materials" [309] is *Pipe Technology*, where different artists, both interested in working with pipes, managed to assemble an artefact that combined their absurd concerns.

Understandably, online and virtual mediations had a drastic impact on the workshop (as for the whole NIME 2020). Given the constraints/opportunities of that NIME edition we had to make available communication technologies part of the game. Rather than looking for the most efficient tool, we decided to "embrace the glitches and limitations of current remote and collaborative technologies" [8]. We also encouraged our participants to consider possible distortions and jitters as absurd source of inspirations. As mentioned in the workshop webpage :"by relaying ideas through different, partially broken, modes of communication, we thus allow the network to have some agency in how exquisite musical ideas play out". The Google Slides workspace definitely shaped the workshop outcomes and processes. Some obvious influences: the chosen environment privileges visual materials over any other kind of media and it imposes a linear narrative. According to the approach described, we then emphasised such features, for instance, suggesting participants to create variations of existing ideas so to create "linear taxonomies" of absurdities.

8 See workshop webpage – last access April 14, 2023.

Finally, organisers and mentors influenced the events in various ways. For instance, interested participants would often apply to our activity because they knew (directly or indirectly) the invited mentors. Being part of existing networks (e.g. e-textile community) organisers and mentors somehow contributed to indirectly select the people eventually involved. Although during the workshop organisers did not particularly intervene and their influence was relatively constrained (e.g. making sure to keep the event on schedule), various hackathon participants identified as a strong source of inspiration the invited mentors.

Hackathon mentors found themselves engaged in a variety of activities, some intended in advance (introducing the themes of the hackathon, presenting some of their own work, offering advice and constructive criticism), others emerged as the hackathon unfolded (creating solutions for problems where participants were blocked on details, making their own absurd designs when time became available, offering wilfully absurd advice through a random selection from a book of aphorisms written during the event). In these ways, we felt that the specifics of doing an absurd hackathon suggested the beginnings of an absurd design pedagogy - something we intend to develop further in future work.

5.5 CHAPTER CONCLUSIONS

The research presented in this chapter focused on the discovery of subjective techno-musical knowledge and visions through the playful perspective of absurd making.While framing their own notion of musical absurdity participants engaged with what they identified as familiar and granted in order to de-situate it. Participants then often retrieved ideas and representations linked to their cultural contexts as well as their previous experience with music technologies, digital tools and materials.

Overall, the activity here introduced should not be interpreted as an attempt to dissect subjective factors from the cultural and the technological. These elements indeed always co-exist in all the musical artefacts introduced in this dissertation. Our intention was instead to promote design activities which could clearly expose designer's personal attitudes and views. The specificity of the artefacts presented in this chapter then arises in the particular ways technologists assembled different elements, including individuals' cultural background and technical skills.

From this viewpoint, absurd making turned out to be a powerful tool that, as a sort of magnifying glass, helped to adjust our gaze and catch some glimpse of

uniqueness. This approach allowed us to engage with creations and reflections that would be difficult to earn with more traditional and standardised methods. By moving away from classical design attitudes, and looking at more subversive approaches, we hoped to question both our own practice and the routines we sometimes encounter in academic and research areas.

From this viewpoint, we introduced our events with the intention to support those NIME sub-communities with similar concerns to those expressed in this chapter. This based on the impression that within strongly techno centric contexts, researchers interested in this kind of playful (yet serious) work can feel quite isolated, if not surrounded by scepticism. Our goal was then to build on existing networks and initiatives over which researchers can draw on for confidence, ideas and inspiration. On this note, we were impressed by the energy and enthusiasm that our participants expressed throughout the two events.

We discussed absurd making as a lighthearted approach to (un)veiling personal design perspectives and support relexive making. We showed how this permissive and open-ended attitude allows for the emergence of creative obstructions which question technological assumptions, musical practices as well as the perception of the familiar and the domestic [36]. As something "made strange" requires more attention, absurd making then provides a valuable framework to discover our own expectations – something that is difficult to see because we see through it [14]. Furthermore, in the context of our research, the notion of the "musical absurd" can be regarded as highly personal as participants were encouraged to frame it at their leisure. This offers us the potential to make use of absurd making to produce a kind of design visions hooked to the individual makers and embedded into the narratives they participate in.

Overall, our work aims to contribute to those HCI research fields that explores critical making as a disruptive and playful practice, e.g. [109, 374]. We see our findings and reflections close to the ludic and fictional approaches articulated by Vines et al. and Blythe et al. [357, 54], where fragile, cheerful and sometime naive design ideas become useful prompts to acknowledge the complexity of design *problems* and the limitation of our *solutions*. In line with the considerations proposed by [16], our project wants to highlight the value of subjective, diversified HCI accounts with no need for immediate impact.

Within the NIME research domain, we suggest absurd making as a powerful tool to made manifest subjective views which condition the development of musical interfaces. Our research presents particular affinities with the work of Bowers

and Green [71] and Andersen and Wakkary [14, 10], where ironic and thought-provoking design explorations are exploited as means to generate critical and personal design knowledge. The works here presented then provide an account on how the discovery of the contradictions introduced by unconventional artefacts can help to generate awareness and advance the debate around the complex and multifaceted nature of contemporary musical instruments.

6

A PRACTICE-BASED ACCOUNT

This chapter incorporates significant material from 'Mirroring the Past, from Typewriting to Interactive Art: an Approach to the Re-design of a Vintage Technology' by Lepri, and McPherson originally published in the proceedings of the International Conference on New Interfaces for Musical Expression, NIME 2018 [227] and 'Exploring Participatory Sound Art' by Gourdarzi, Gioti, Lepri and Morreale originally published in the proceedings of the International Computer Music Conference, ICMC 2019 [145] – more specifically, only section 2 of the ICMC paper is here repurposed as it is original material written by Lepri at first-hand.

This chapter introduces the Cembalo Scrivano, an interactive audio-visual installation I developed during the course of my PhD. The intention is to apply the reflections advanced in previous chapters as a framework to explore the diverse roots of the artwork. I therefore introduce a first-person and practice-based report on the evolution of the project drawing parallels with the themes explored in previous chapters, and examining their analytical relevance. The composition of the interface is then assessed to uncover cultural and material influences as well as personal design intuitions and judgments. After presenting the main technical and aesthetic features of the piece, I attempt to identify the key elements which contributed to the emergence of the artefact, also delineating some of the complex relationships which hold them together. The final discussion highlights the interdependencies between the socio-technical, aesthetic and subjective factors that shaped the Cembalo Scrivano project.

6.1 BACKGROUND

In previous chapters I Introduced a set of practical investigations exploring how cultural values, design tools and subjective visions can condition the work with and on DMIs. Chapter 3 considers how different communities of practice and cultural contexts contribute to produce divergent conceptions of the musical instrument, which affect its design and uses. In Chapter 5 I presented an approach to

expose subjective intuitions and perspectives so that they can be critically acknowledged and creatively (ab)used for the ideation of new musical artefacts. Chapter 4 instead examines how specific digital music tools and materials might influence the work of practitioners by sustaining specific musical notions. The present chapter has a dual function. On one side it provides further evidence supporting the propositions articulated in previous chapters. On the other, it illustrates how the framework explored in the thesis can be applied to critically unpack and better understand the ideation, design and use of a given DMI. The chapter then offers a self-reflexive analysis which situates, consolidates and puts to work the insights hitherto described in the context of an audio-visual artwork I developed over the course of three years.

As mentioned in Section 2.3, third HCI wave brought into view self-reflection as a valuable attitude to critically investigate emerging issues in design research – see among several others [322, 165, 286, 306]. Within this context, first-person [1] and autobiographical research methods have been proposed to produce new design knowledge [181, 279]. Often drawing on ethnography and anthropology [18], "first-person research involves accounts of living with technological systems, at times built by the researchers themselves" [108, p. 745]. In general, these approaches acknowledge the importance of felt-experience in technological interaction [254]: given its embodied and emotional implications, felt-experience might be best captured through user and designer's first person perspective [180, 183].

First-person contributions have a varied history in the context of music technology. Since the early experimentations, up to the establishment of electronic music studios throughout the world, composers and technologists would often write about their work. Beside discussing the techno-scientific knowledge gained through practice, these first-person accounts often include comprehensive art statements and detailed aesthetic discussions – just to mention one example amongst many, see Xenakis's *Formalized Music* [378].

The rise of the techno-scientific culture, which promoted a techno-centric fragmentation of the field (see Section 2.2), led to an epistemological disequilibrium, where standard *music technology contributions* are today characterised by scientific mindsets, in which the researcher – as an external and neutral observer – should let the evidences collected speak for themselves [170]. Gurevich describes this trend while reflecting on the diversity of research inputs accepted at the NIME confer-

1 See the First-Person Research Methods Workshop held at DIS 2019 conference - last access April 14, 2023.

ence, thus showing how scientific and technical contributions gradually became more popular throughout the years [153].

Nevertheless, since the first NIME workshop, we can find many examples of practice-based research which, despite having no scientific claims, introduced valuable contributions for the development of the field [2]. Gurevich describes these works as those which "report on specific interfaces or novel systems, and whose primary contribution is either manifest in the design itself or a theoretical position that the design articulates" [153, p. 81]. Although Gurevich acknowledges the possibility of overlaps, he considers "qualitative research" as a different type of NIME contribution, including in this category "ethnographic or experimental research studies with descriptive results".

In Gurevich's terms, this chapter can be considered as a qualitative and descriptive report which aims to combine practice-based and (auto)ethnographic perspectives. The intention is to provide a *practitioner-researcher* perspective [90, 203, 148], where the interface designer is also a critical commentator of his own work and results – see Section 2.1. Early examples of such accounts include the musical considerations and design suggestions advanced by Chadabe [92], Waisvisz [360] and Cook [97]. First-person contributions, often resulting from long-term practices, are recently becoming more reported in the NIME contexts. Examples of such contributions relate to NIME pedagogy [347], machine learning based instrument design [128], musical imagery [303] and DMI apprenticeship [384].

Taking inspiration from this body of research, I aim to describe the making of the Cembalo Scrivano and discuss its evolution in light of the socio-technical dynamics reviewed in previous studies. First, I introduce the artwork, providing an overview of its main technical and aesthetic features. I then describe some of the elements which facilitated the configuration of the interface. This first-person account focuses on the mutual influence between the tools and materials used, the socio-cultural settings out of which the artwork emerged, and the musical knowledge I inscribed into the interface. The reflections articulated in the final sections further consider how can we inspect and interpret cultural, materials and subjective factors in view of their complex interconnections and in reciprocal determinations.

2 See, for example, the reflections presented at the Practice-Based Research workshop at NIME 2014 – e.g. [203, 152] – workshop website currently unavailable.

6.2 CEMBALO SCRIVANO

The Cembalo Scrivano is an interactive installation based on an augmented typewriter. By detecting the performer's typing activity, it generates in real-time audio and visual materials. After providing a description of the overall system architecture, I introduce two different iterations of the piece. The first design has been developed to fulfil an assignment of the Interactive Digital Multimedia Techniques (IDMT) module I attended during the first year of my PhD. The second version of the Cembalo Scrivano is the result of a collaboration with Fabio Morreale [3], who was research assistant at the Augmented Instruments Laboratory in the same years I was involved in the lab as PhD student. Both iterations were presented in different public events and venues (mainly London based initiatives) throughout 2016 and 2018.

6.2.1 *System architecture and setup*

The typewriter used in the project is an Olympia SM9 which was distributed with a custom suitcase for transport – see Figure 6.1. The audio-visual interactions are based on the detection of the keys pressed by the user. Each key is connected to a metal bar that passes through the bottom of the machine. Once a key is pressed the bar slides down for few centimetres. In order to detect this movement, I used a touch sensor under the machine: a membrane potentiometer in the first version and two Trill sensors [4] [257, 383] in the second iteration of the artwork. The sensor was placed on the base of the typewriter suitcase. By shifting down, the various bars touch the sensor in different points – see Figure 6.2. In this way, it was possible to assign a specific position-region of the sensor to a specific symbol of the keyboard. This procedure is at the basis of all the new interactive elements developed.

The energy detected by the sensor is converted into digital information using the Arduino Uno board. First, the data are processed in order to: (i) associate the sensor values to specific ASCII values, (ii) control the behaviour of eight LEDs placed within the typewriter. After these processes, the detected ASCII values are sent to a computer and processed using Max and Processing. Processing is used to generate and manipulate the visual elements associated with the typed

3 See Fabio Morreale website - last access April 14, 2023.
4 See the Trill Touch sensor family – last access April 14, 2023

Figure 6.1: The Olympia SM9 typewriter used in Cembalo Scrivano installation.

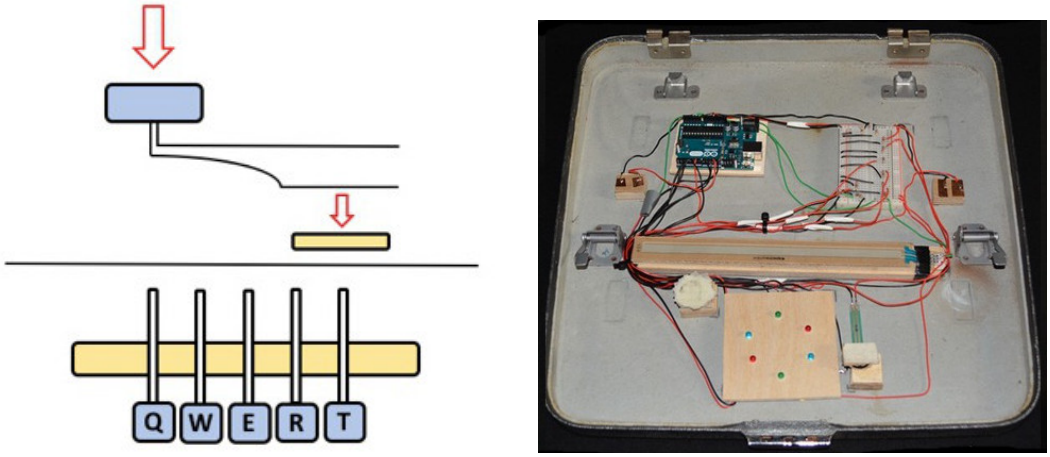


Figure 6.2: The sensing mechanism (right) - by pressing a key (blue) the metal bars touch the potentiometer (yellow) in a specific point; the Olympia SM9 suitcase base equipped with Arduino, sensors and LEDs (left).

letters. Max is used to produce the sonic materials linked to the typing activity. The communication between the various hardware and software units is based on serial port (Arduino to Processing) and Open Sound Control (OSC) (Processing to Max).

The Cembalo Scrivano is conceived for intimate and silent spaces. This to evoke a deep and almost meditative writing activity: a quiet, private and focused practice. The Cembalo Scrivano should be therefore set up isolated within a small-sized room, in which the audience can interact with the machine individually or as a small group. Moreover, in order to appreciate the changes of light occurring

within the typewriter, the environment should be dimly lit. Ideally, the generated images should be projected on a wall behind the typewriter and the audio signal diffused trough a stereo PA system. Alternatively, the video can be displayed using a computer screen placed on top of the typewriter and the sonic output can be listened to via headphones.

6.2.2 *System interactions and aesthetics - first version*

The interactions of the first version of the system – Cembalo Scrivano .1 (CS1) – are based on a simple two-state paradigm. The first state is associated to a condition of quietness. If the keyboard is not touched (i.e. no letters are typed for more than ten seconds) a constant low frequency drone like sound is generated. This tone, with fundamental frequency around 180 Hz, is characterised by a beating effect. Simultaneously, LEDs located on the bottom of the machine constantly fade in and out. These slowly change their brightness and contributes to the pulsing effect already introduced through the drone sound. Besides the slow and constant LED fades, during the quietness state, no visual feedback is generated.

If a key is pressed, the system switches to the second state. The LED behaviour immediately changes: from slow and dimmed to impulsive and bright: LEDs turn on only for the time a key is pressed. The drone sound shifts to a higher frequency (fundamental frequency around 800 HZ) and decreases in amplitude and additional sounds are added: short pre-recorded samples of the typewriter mechanics. For each pressed keys various samples are played simultaneously at different speed rates. In addition, some of these audio samples are sent to a feedback delay line with delay times randomly generated between 2 and 500 milliseconds. Overall, the sonic materials produced are characterised by impulsive envelopes with glitchy and flickering decays.

The letter associated to the pressed key is also visually generated – see Figure 6.3. The letter is randomly located on the screen and it *lands* to its final position by moving with different behaviours. While landing the letters produce a trail that stays until the screen is refreshed (space bar on the typewriter). The juxtaposition of the various trails contributes to the generation of abstract shapes. While interacting with the CS1, it is increasingly difficult to keep track of the various typed letters. Furthermore, the ways the letters appear is characterised by fast oscillations and shakes. This aim to establishes a direct connection between the generated visual

and sonic behaviours – i.e. shaking letters and glitchy sounds [5].

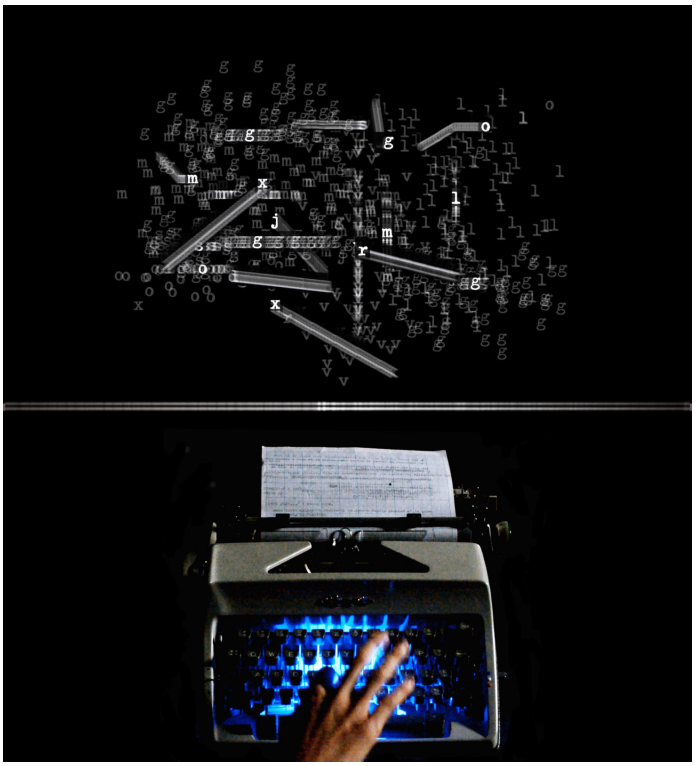


Figure 6.3: A view of the visual output generated by the CS1.

6.2.3 *System interactions and aesthetics - second version*

The Cembalo Scrivano .2 (CS2) holds the same two-states logic of the first version, however the interactions were further developed to provide a more varied and engaging experience.

First, we sought to stimulate audience participation by making the typed text intelligible. Rather than rendering each letter in a different place, the visual algorithm displays longer sequences of inputs consecutively, thus enabling the audience to read words and sentences. The interaction has been implemented so that the audience could see what the current performer is writing. Users might then get some inspiration from previous "writers" and potentially build on previous inputs. Like in the first version of the installation, while being displayed letters are followed by a trail which slowly disappears. Sentences composed by different

5 See a teaser of the CS1 - last access April 14, 2023.

users are placed in different areas of the screen: a new location is set once no typing is detect for more then a few second – see Figure 6.4). After being displayed for a few seconds, letters and sentences slowly fade out.

Figure 6.4: A view of the visual output generated by the CS2.

Second, we introduced a memory feature. The CS2 keeps track of audience input and repurposes small portions of the texts previously typed. After some minutes of interactions (i.e. once enough data are gathered), the system starts to present fragments of previous sentences. The rendering of past inputs is accompanied by sounds – those normally played during the typing activity. We introduced the memory feature with the intention to provoke the audience creative writing for the generation of new inputs. It is possible to set how often the system would retrieve previous inputs based on a probability value within a given timeframe. We used to tune this parameter based on the context of each specific exhibition. We usually set the memory feature to be called every five minutes or so.

Third, we re-designed the audio-visual interactions based on the amount of typing performed by the audience. Similarly to the first version of the installation, the second state of the machine is triggered when a key is pressed. Once the system shifts to the typing state, the various sounds are organised following an "activity" metaphor. The typing activity is interpreted in relation to the quantity of energy injected into the system: a leaky integrator inspired algorithm based on a counter which increases when a letter is typed and slowly decreased if no keys are pressed. Slow and short typing is associated with low energy levels, while fast

and continuous writing gradually increases the amount of energy detected by the system. Low activity produces quiet and discrete audio-visual events; high activity produces dense, articulated, and loud sequences of sound and visuals.

Finally, we composed three new audio-visual environments for the installation, each related to aesthetic and symbolic elements linked to the artwork: the machine, music and written language. In order to provide diverse musical and visual interactions, the three scenes are constantly alternated for the entire duration of the exhibition / performance. A short description of each audio-visual environment is below provided [6].

- **Machines** – the sounds designed for this environment are recorded samples and synthesised sounds evoking mechanical gears and automated machineries. Following the activity metaphor, the system alternates short, punctual and granular sounds with denser and louder metallic sonorities. The visual shows the typed letter that randomly roams throughout the screen leaving a trace behind it. The behaviour of the tail is entirely decided by stochastic processes, calling for reflections on delegating controls to the machine.

- **Instruments** – pre-recorded instrumental sounds are used as sonic material (mainly short samples related to Western monophonic classical instruments). The section was conceived to feature the way music is traditionally interpreted, although reinterpreted with a contemporary aesthetic (e.g. once triggered, each sound is manipulated by changing the original speed rate). The result is a mix of timbres oscillating between traditional music instruments and abstract sonorities. The visual displays the typed letter as an exploding entity while at the same time maintaining a harmonious behaviour, mirroring the tension between the acoustic and synthetic sounds.

- **Voices** – sampled male and female voices speaking different languages (English, Italian and German) are used as sound material. Although it is possible to perceive the various voices, they were designed to offer a degree of ambiguity by means of segmenting and overlapping the samples. This choice was motivated by the idea of not filling the composition with clear semantics, to avoid influencing the audience interacting with the system. The sounds vary from whispering to loud speaking. The shift between the different vocal

6 See a short demo of the CS2's audio-visual interactions - last access April 14, 2023.

qualities is organised following the activity paradigm: slower typing generates quiet and soft articulations while fast typing produces louder and more dense voicing. The visual matches the concept of human voices by displaying abstract representations of mouths that open and close.

As in the previous version of the system, the sonic and visual features of the CS2 were designed around a single user paradigm. From an interactive viewpoint, we then consciously embraced the cultural assumption for which a typewriter should be used by one person at the time. By making the text intelligible and introducing the memory feature, we then explored a process of writing and musicking that is sequential and, to a certain extent, collaborative.

The challenge was then to stimulate audience engagement by staging single participant's interactions and allowing the public to participate in the creative process one after the other – possibly building on what the audience did in the past by retrieving previous inputs. Such an approach relates to the dynamic relation between the system and the performer/user that often characterises digital installations and participatory artworks [103]. In our context, audience members might then alternatively take part in the installation as users, performers and spectators [7].

6.3 A COMPLEX SYSTEM OF MEDIATIONS

In this section I introduce a series of factors which contributed to assemblage of the Cembalo Scrivano. Far from presenting an exhaustive review of the many sources responsible for the emergence of the interface, I provide a few basic, yet specific, elements which relate to the subjective, cultural and technological influences delineated in previous chapters. I then seek to illustrate how the formation of a digital artwork is distributed amongst different factors, and how the creative process "takes place in all the interstices between these successive mediations" [175, p. 87].

6.3.1 *On musical cultures and communities of practice*

In what follows I provide some examples on how my direct involvement with different communities contributed to shape both material and conceptual features of

7 Indeed, in the context of this chapter, the terms *user* and *performer* should be considered as equivalent

the Cembalo Scrivano. Overall, the autobiographical observations here introduced suggest that, alongside the production of shared representations and assumptions, communities of practice might also influence the physical assemblage of a digital musical artefact.

A material oriented approach

I first developed the Cembalo Scrivano to accomplish the assignment of a module I attended during the first year of the Media and Arts Technology (MAT) PhD programme. The IDMT module was thought by Andrew McPherson and Becky Stewart [8] and aimed to provide students with basic knowledge on a variety of interactive media and techniques. One of the course assignments involved the design of an interactive artefact based on the tools learned in class. Students were invited to present their projects at CruftFest: a mid-term internal showcase in which the MAT and QMUL communities could experience the works developed for the assignment. The Cembalo Scrivano was showcased for the first time for this occasion.

As examined in Chapter 3, the knowledge and practices shared within communities, can considerably affect the understanding of musical tools and purposes. Despite being the IDMT module the actual reason for starting the project, both the course and the MAT programme had crucial influences on the early developments of the Cembalo Scrivano. During the first year of my PhD I had constant and intense interactions with both classmates and senior PhD cohorts. Indeed, especially towards these kind of hands-on assignment deadlines, students used to work closely in the same facilities for various weeks (e.g. workshops and computer rooms). The same spaces were also used by older MAT students and research staff. While assembling the Cembalo Scrivano I had the chance to show my work and receive comments from the MAT community. Above all, such supportive and sympathetic confrontations helped me to set the artistic and technical scope of the project, aiming to level with the work of my colleagues.

The IDMT course promoted a practical approach to technology design, focusing on the demonstration of interactive tools without explicitly introducing any particular HCI theory or reference. Such technical attitude is often found in engineering and science departments, but also widely spread in many other sectors of the the Anglo-Saxon culture. As we were encouraged to use the techniques intro-

8 See Becky Stewart and Andrew McPherson websites - last access April 14, 2023.

duced during the module, tool and materials often functioned as starting points for the assignment projects. For the CruftFest assignment, we were asked to build an interactive project recycling a discarded object. The IDMT lecturers suggested students to fetch forgotten items and old *junk* in the many London's secondhand markets and charity shops.

Following this advice, I bought the typewriter at Deptford Market [9] for £ 5. Unlike the Cembalo Scrivano, many of the projects presented at CruftFest were based on the creative re-use of found electronic devices, abandoned machines and second-hand instruments. The design approach introduced by the IDMT module set a *material-oriented* perspective similar to the one described in Chapter 3. Based on this outlook, I soon found myself confronting with the available materials and tools, and, in dialogue with them, I gradually develop an idea for the project.

The actual classes taught during the IDMT module also had various influences on my work from a material viewpoint. The materials examined during the course (e.g. Arduino, common sensors and circuitry) often resulted to be powerful sources of stimuli. Many of the Cembalo Scrivano features are a direct consequence of my exploration of these tools and techniques. For instance, the idea of a visual output, with moving letters leaving a trail behind, was directly inspired by a Processing lesson delivered by Becky Stewart. Andrew McPherson's interaction design classes also affected various aspects of the project. Andrew's passion for the design of detailed and nuanced musical interactions, pushed me to carefully interpret the sensors's data and avoid, as much as possible, the implementation of dummy MIDI-keyboard like interactions.

Finally, the IDMT module also introduced broader material and technological concerns which contributed to shape the Cembalo Scrivano project. The invitation to reuse existing objects and electronic devices was presented as a sustainable practice in light of the alarming increase of electronic waste in Western societies [10], an approach concerned with fundamental social and environmental issue. To a certain extent, these widely shared ethical and political views ended up informing the development of my project.

9 Deptford Market is a second-hand, antiques and bric-a-brac market located in Deptford, south east London.

10 Waste of electronic equipment is one the fastest growing waste streams. In the European Union, 9 million tonnes of electrical waste were generated in 2005, and expected to grow to more than 12 million tonnes by 2020. See the EU policy web page on electronic waste – last access April 14, 2023.

Engaging with the audience

Another socio-cultural element that affected the development of the installation relates to the modalities through which different audiences interacted with the artwork. Over the course of two years, different versions of the Cembalo Scrivano have been presented at various musical events and digital art festivals. These include Dorkbot London [11], Hackoustic meet-ups [12] hosted by Iklectik [13], Ars Electronica Campus [14] and the Institute of Electronic Music and Acoustics (IEM) [15].

These exhibitions gave me the opportunity to appreciate how the Cembalo Scrivano was perceived in slightly different ways depending on the socio-cultural context in which it was presented. The mentioned venues are indeed quite different in terms of format and audiences. Ars Electronica is an enormous event which, alongside a specialised public interested in digital art, also attracts a more general audience – hundreds of people visited the fair everyday over the course of a week. Similarly, but on a much smaller scale, Dorkbot London brings together a variety of people, as the Dorkbot slogan says "people doing strange things with electricity". Each Dorkbot event presents talks and demos on the more disparate topics, and the meet-up attracts an assorted crowd of technology enthusiasts and practitioners.

Out of this heterogeneity of spectators/users, the most recurring element characterising audience interactions was the familiarity with the device. The mere presence of the typewriter would then function as a strong incentive to engage with the installation. Typically a person would approach the artwork with a good degree of confidence, immediately reproducing those behaviour normally associated with a typewriter (e.g. fast typing, resetting the carriage lever, adjusting the platen knob).

11 Dorkbot London is a periodic informal gathering of artists, engineers, designers, scientists, inventors working under the umbrella of electronic art, see Dorkbot London website – last access April 14, 2023.

12 Hackoustic is a London-based artists-led initiative dedicated to instruments building, hacking and sound art, see Hackoustic website – last access April 14, 2023.

13 Iklectik is a London-based creative platform and venue showcases contemporary art, experimental music and artistic critical practice, see Iklectik London website – last access April 14, 2023.

14 Ars Electronica Campus is an exhibition, part of the Ars Electronica festival (Linz), by artists associated with an international higher-education institution, see Ars Electronica website – last access April 14, 2023.

15 IEM is an academic research institution based at the University of Music and Performing Arts (Graz), particularly active in the fields of computer music and digital art as well as signal processing and acoustics.

I could often notice that the Ars Electronica and Dorkbot audience would gradually start to question the nature of the device while interacting with it. For instance, once they realised that the words typed were not rendered as expected, they would began a more detailed inspection of the installation's visual elements. Such explorations would often lead the public to speculate on the metaphorical and symbolic implication of the artwork, sometime asking me to elaborate on its origins and meanings.

While observing the broad and diversified public encountered in events such as Ars Electronica and Dorkbot, I could therefore appreciate some of the most frequent and distributed reactions elicited by the artwork. The acknowledgement of these cultural forms, intended as "cognitive, physical, and emotional resources" [184], directly informed some of the design choices I took in the successive iteration of the piece. For instance, for the CS2, I decided to render words and sentences in a more intelligible way. A decision made after realising that the "general user" would most likely privilege the visual output over sound and music. The CS2 can be then considered as an attempt to second the text-based affordances elicited by the machine, while also introducing more complex and varied musical materials.

On the other hand, Hackoustic and IEM venues usually gather a specialised audience, often directly engaged with the fields of instrument design and computer music. Notably, compared to the rest of the public, people with a background in music technology would often approach the installation in different ways. While discussing the CS2 installation, expert music technologists often considered the text-based semantic features as a limitation, occasionally proposing solutions to further "shift the focus of the performance from the semantic content of the text input to the sonic interaction with the interface" [145].

During the Hackoustic and IEM events, people would often comment on the installation in terms of *control* on the *composed output*, occasionally criticising the Cembalo Scrivano interactions for being too basic with limited control possibilities. Rather than scrutinise its poetic and symbolic connotations, music technology practitioners would typically focus on the functional dimensions of the piece. Occasionally, the Hackoustic and IEM audience would also comment on the formal development of the installation. Notably, the people able to appreciate the alternation of the three audio-visual environments were generally musicians [145]. Compared to the Hackoustic and IEM events, during the Ars Electronica and Dorkbot exhibitions, musical comments, whether on the structure of the piece or on the

relationships between gestures and sounds, were essentially absent.

Despite my attempt to describe some of most common tendencies, the relationships between performers and the artwork are hardly generalisable. The modalities through which the Cembalo Scrivano was interpreted were influenced by many factors. For instance, the setup and location of the installation, as well as the events format, drastically impacted the perception of the artwork. In the Ars Electronica showcase I could setup the installation in a small, private and quiet environment. It was not possible to recreate the same conditions for the Hackoustic and Dorkbot events where the Cembalo Scrivano was installed in a large and open-space while many other artists were demoing their work.

The IEM event significantly diverged from the gallery / exhibition format of the other venues. In this context, the piece was presented as part of a concert during which the audience could interact with various participatory installations one after the other. The IEM concert format put more pressure on the participant-performer, whereas the gallery spaces supported more relaxed and playful interactions. Moreover, while the concert format was excellent for catching audience attention, it also introduced some time constraints as the audience could interact with each piece for about 20-30 minutes [16]. While isolated space resulted ideal for the experience of the Cembalo Scrivano, shared spaces did not facilitate the fruition of the work. Since the Hackoustic and Dorkbot locations were rather noisy and dispersive, the interactions with the systems were often hasty and superficial.

Involvement with communities of practice

As illustrated in Section 2.3.2, while examining the learning processes amongst practitioners in a social context, Lave and Wenger introduced the notion of *community of practice*. Lave and Wenger suggest that new members gradually become integrated, acquire new skill and contribute to the community through *legitimate peripheral participation* [218]. In the following paragraphs I describe how my affiliation with different communities of practice, and the progression through different levels of participation, conditioned the evolution of the Cembalo Scrivano.

After the first year of the MAT programme, in which students were required to take a series of taught modules, I could move to the actual PhD stage. While settling in the MAT research community, I was expected to find a supervisor for

16 See the recording of the CS2 performance at the IEM concert (made for research purposes), kindly provided by Visda Goudarzi - last access April 14, 2023.

my PhD and become associated to one of the QMUL research groups. I therefore became a member of the Augmented Instruments Laboratory (AIL) which is part of the Centre for Digital Music (C4DM) at the Electrical Engineering and Computer Science department of Queen Mary University of London. Becoming affiliated with these academic communities provided me with opportunities to showcase the Cembalo project.

For instance, I gradually became involved in the organisation of various research and dissemination activities coordinated by the MAT programme (e.g. Inter/sections [17] and Ars Electronica Campus). Through these events I had various chances to publicly present and discuss the Cembalo Scrivano. Similarly, C4DM colleagues would sometimes propose me to showcase the installation at local events they were involved with – e.g. Dorkbot London.

Instead of presenting the same "untouched" installation, for each showcase I would often explore a slightly different version of the piece – e.g. experimenting with new interactive features, re-tuning the audio and visual mappings or simply modifying the algorithm's parameters. In this way the installation gradually transitioned, through a constant process of trial and error, from the first CruftFest prototype to the second version. Having access to the MAT studio and workshop facilities, I could improve the installation over the course of various months. Furthermore, my affiliation with the AIL group also resulted to be essential for the evolution of the artwork. While working on the interface, I received great support from the group which led to the implementation of a more reliable sensing system, featuring the Trill sensor technology.

Being part of the Augmented Instrumets Lab, I gradually became acquainted with the group members, also discovering their musical and research activities. Through this process I met Fabio Morreale and, during the second year of my PhD, I asked him to join the Cembalo Scrivano project. I knew Fabio had an interest in generative art and various experience in the design of audio-visual interactions [18]. Fabio is currently active in the context interactive audio-visual installations as composer and researcher. Despite bringing his own sensibility and artistic references, Fabio considerably expanded the technical scope of the projects – e.g. introducing

17 Inter/sections is an annual event organised by the PhD students of the Media and Arts Technology Centre for Doctoral Training around the themes of digital art and new technology research. See the Inter/sections website – last access April 14, 2023.

18 See for instance Fabio's mobile apps work on generative graphics – last access April 14, 2023.

rather advanced image processing techniques (shader graphics).

Finally, it is worth noticing that the Cembalo Scrivano journey has been influenced by the broader academic communities I am part of: NIME and SMC. A paper describing the Cembalo Scrivano's design approach and theoretical implications has been accepted at NIME 2018 [227]. The comments received by reviewers as well as the conversations I had with the conference attendees solidly contributed to evolve the conception of the piece.

Through the SCM community I could instead find new opportunities to showcase the artwork. Right after Fabio's involvement, I came across a call for collaborative and participatory digital artworks launched by IEM members Visda Goudarzi [19], who I met a few months ago at the 2017 Audio Mostly conference, and Artemi Maria Gioti [20].

Although the exploration of audience collaboration was not originally part of our plan, we considered the call as a good opportunity to get some work done in view of a concrete deadline. We then decided to further expand the elements we were already developing to include some sort of collaborative dynamic. The idea of retrieving previous inputs to inspire current audience actions emerged out this need – see the memory features previously introduced.

6.3.2 *On digital music tools and materials*

The tools and materials used in the project shaped the character of the Cembalo Scrivano since the early stages. I below present a selection of mediations linked to two main perspectives. First I consider how the investigation into the history of the typewriter set the artistic premises of the artwork. Second, I reflect on how the tools employed conditioned the development of the project from both aesthetic and functional viewpoints.

Shaping past-new technology

Intrigued by the rescued typewriter, I began to do some research on the history of the Olympia SM9, and more broadly to investigate the genesis of typing devices.

19 Visda Goudarzi is a music technologist and performer currently working as assistant professor at Columbia College Chicago. With Artemi, Visda is member of the *Intra-sonic* electronic duo, see the Intra-sonic webpage – last access April 14, 2023.

20 Artemi Maria Gioti is a composer and researcher currently working as principal investigator of the artistic research project Inter_agency, see Artemi website – last access April 14, 2023.

Through this examination I discovered the field of *media archaeology*. In media theory, media archaeology is often related to the study of new and emerging technologies by taking into account the history and evolution of media [290]. These cultural studies focus on the critical scrutiny of forgotten devices, observing that new media often renovate old interactive paradigms and communication techniques. Besides being an approach to media and technology studies, media archaeology is also understood as an artistic practice. Artists involved with media archaeology practices often exploit notions such as *past-new media* (the paradox for which "new media always becomes old") and *zombie media* (an out of use media which is "resurrected to new uses, contexts and adaptations") [176].

Through this material-oriented investigation I learned that typing devices have been used in different artistic contexts, including interactive arts, audio-visual installations and digital music performance [21]. The NIME literature offers various examples of such re-interpretations. For instance, Nash augmented a computer keyboard to capture velocity and other continuous musical properties, in order to enhance expressive interaction with music software [278]. Armitage instead explored alternatives to the QWERTY keyboard as physical interface to laptop live coding by augmenting a stenotype keyboard which permits continuous gestural control of keys [23].

The most crucial discovery I made while researching on the typewriter relates to the work of the the Italian inventor Giuseppe Ravizza, which in 1855 created one of the early example of modern writing device [2]. This machine is considered a precursor of the later Sholes and Glidden Type-writer – the first commercially successful writing machine, invented in 1868 – as Ravizza's model features noticeable similarities with the Sholes and Glidden design. Ravizza called his invention *Cembalo Scrivano* (Scribe Harpsichord) due to the usage of piano-keys – see Figure 6.5. Fascinated by Ravizza's work, I started to develop the interactive paradigm of the installation. What if the machine invented by Ravizza had not been forgotten? How would a contemporary interpretation of the device look like today? More specifically, how to re-interpret the Cembalo Scrivano and re-purpose some of the ideas embedded in Ravizza's machine?

Ravizza's invention reworks the harpsichord interface: an existing musical instrument was used as source of inspiration for the development of a new machine – from art technology to typewriting. An inspiring and comprehensive history of

21 See for instance this collection of artworks – last access April 14, 2023.

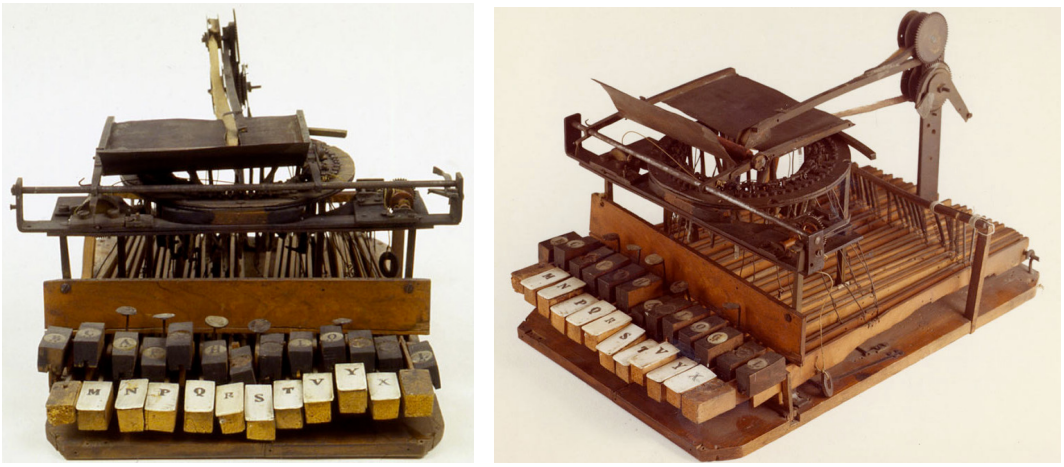


Figure 6.5: The Cembalo Scrivano invented by Giuseppe Ravizza in 1855. Picture retrieved from Museo Nazionale della Scienza e Tecnologia Leonardo da Vinci, on-line archive – last access April 14, 2023.

typewriting is provided by Kittler in his "Gramophone, Film, Typewriter" [213], which thoroughly depicts the important place of the typewriter in media theory and history. According to Kittler, Ravizza, and other early inventors of typing machines, originally constructed their typewriters for blind and/or deaf people. Typewriters were then originally proposed as machines that could aid individuals with neurophysiological impairments. Kittler then suggests how this association reveals how in the late nineteenth century the representation of the brain as a machine was starting to emerge [Ibid. p. 189].

Inspired by the Cembalo Scrivano, I then decided to mirror the process done by Ravizza: to convert a typewriter into an interactive art installation – from typewriting to art technology. Ravizza borrowed the Harpsichord's interactive paradigm for the implementation of his machine: instead of playing notes, by pressing the keys the machine prints symbols. The idea behind my installation was to adopt the same design approach but establishing the inverse analogy. Oscillating between two domains (musical and literary), the same technology travels across history, carrying knowledge, behaviours and meanings (see Figure 6.6).

Based on these ideas, I develop an interactive system that could be used in the context of interactive sound and visual art. The shift from typewriting to digital art was then realised by twisting the results of the interactions normally associated with the source object. Both machines share features with the technologies to which they refer. For instance, both the Cembalo Scrivano and the harpsichord produce specific punctual events (letters and notes) by pressing the keys with the

fingers. Likewise, my installation is based on the same principle of the typewriter: in order to modify the system's output, it is necessary to convey physical energy through fingering activity. Rather, the final goals of the interaction have been re-established and shifted into a new domain.

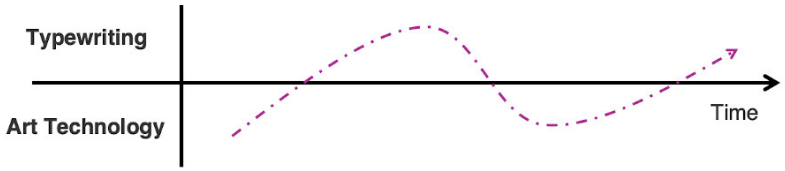


Figure 6.6: Representation of the conceptual approach inspired by Ravizza's machine: the Cembalo Scrivano travels in time, shifting between the domains of typewriting to art technology.

Dealing with digital mediations

Many of the tools and materials I used in the Cembalo Scrivano project were provided during the IDMT module previously mentioned. For instance, at the beginning of the course, each student received an Arduino Starter Kit. I chose to use this platform as it was the most accessible and immediate option – also considering that I had been in London for a few months with no personal equipment. Similarly, the selection of sensors and basic electronic components I used for the project has been made based on the tools and materials covered during the module.

The sensing of the typewriter focused on the key detection. I managed to sense all keys using only one sensor placed under the machine – the membrane potentiometer for the CS1 and Trill sensors in the CS2. I am particularly proud of this solution, for what I consider being a relatively elegant work-around. In this regard, I did not considered the complex typing mechanism of the device, in which various levers are connected to each key, as source of inspiration but rather as an obstacle to overcome. However, compared to the many alternatives I could have picked (e.g. sensing different parts of the machine) this surely was the most obvious and straightforward choice. The intention was to follow those shared norms and assumptions commonly associated to the typewriter, an attitude that resonates with the discussion introduced in Chapter 4, on how previous experiences and situated knowledge influence the uses and interpretation of a given technology.

The audio programming language Max certainly shaped the nature of the interactions composed for the installation. The analysis presented in Chapter 4 attempts to highlight how the approach adopted by Miller Puckette for scheduling real-time tasks often affects the aesthetic output of Max and PD. The "piano model" described by Puckette is based on "a collection of tasks running in parallel" whose timing is controlled by "wait functions and triggers" [300, p. 32]. The CS1 sonic interactions largely reproduce this model, e.g. short samples are triggered only if a key is pressed. In contrast, the introduction of the "activity" metaphor, which translates the amount of actions a user perform over a period of time, can be considered as an attempt to deviate from the "reactive" paradigm promoted by the Max language.

A further easy-to-make procedure supported by Max relates to the design of random features. Random-based processes are indeed broadly used for the generation of the installation's sonic materials. A clear example relates to the selection of the samples to be played once a key is pressed. The three audio environments designed for the CS2 feature more than 20 samples each – respectively machine sounds, musical instruments and voices. The Max algorithm then randomly selects which sample should be played and randomly sets their playback rate within a given range. As a result, the performer has very limited control over the sound performed by the machine, and basically no ability to exactly reproduce previous sequences of sound. From this perspective, the Max patch may seem to be much more creative and productive compared to the low influence that performers have over the sonic output of the system – see the findings and discussions presented in Chapter 4.

The presence of over-obviously reactive processes in the Cembalo Scrivano might also be associated to the use of Processing and Arduino. Both platforms share a similar real-time architecture which is highly dependent on the *loop()* and *draw()* functions, a "wrapping mechanism" that continuously executes and update the lines of code contained in the program.

The use of Arduino and Processing also brought into place various routines often found in creative coding, such as the reuse of available examples. Compared to languages such as Max and PD, my level of expertise with Processing and Arduino is rather limited. While using these platforms, I often relied on the many tutorials available online. The algorithms I designed were made by copying and pasting bits "found code" which I assembled and tuned. An explicit instance of

such hybrid bricolage programming relates to the display of moving letters in the CS1. Moving images on the screen by controlling their position with the computer mouse is a classic Processing first-step exercise [22].

Processing and Arduino certainly facilitate this sort of collagist coding practices. Being both platforms designed for a broad spectrum of users, including musicians and visual artists with no or little experience in computer science, they essentially are accessible versions of established programming environments such as C++ and JavaScript. By taking care of a great amount of tasks and subroutines, Processing and Arduino then present the performer with a reduced collection of functions and structures.

Due to these refined "simplifications", new programs are rather handy to create and manipulate, and, to a certain extent, code snippets can be easily reused and interchanged. While borrowing ideas (and bits of code) around the internet, I inevitably incorporated into the artwork aesthetic notions and techniques produced by the Arduino and Processing communities. As considered in Chapter 4, to "work with a tool" necessarily means to enter in dialogue (and be affected by) the socio-cultural contexts from which the technology come and in which it is used.

6.3.3 *On personal design knowledge*

Out of the many sources that influenced the Cembalo Scrivano project, subjective factors are certainly the most challenging to uncover. Any in-depth introspective confrontation poses demanding biographical (and even existential) questions which are far beyond the scope of this chapter. To overcome this impossibility, I present a selection of references related to specific aspects of my cultural, educational and artistic background which are particularly relevant to some of the artwork features aforementioned. While doing so, I will also occasionally reiterate some of the influences previously introduced, expanding and reformulating them in light of my personal history and outlook.

Technological views

The Cembalo Scrivano has been designed with the intention to combine the physical and the digital, conceiving the two dimensions as linked within a continuum.

22 See for instance the Getting Started tutorial by Casey Reas and Ben Fry on Processing.org - last access April 14, 2023.

Typing on a standard typewriter causes both the production of a sound and the impression of a symbol on the paper. The Cembalo Scrivano then synthesises in the digital domain analogous visual and sonic elements.

The idea of continuity between physical and digital is rather common in HCI and digital art domains [266]. I encountered this notion in the early stages of my training, through an introductory HCI module I attended during my bachelor at the Conservatory of Genoa. More specifically, the concept was introduced by Donald Glowinski [23], the rather brilliant and inspiring postdoc researcher that was teaching the course. Somehow Donald managed to provoke my interest towards the concept and it became one of the conceptual resources I still use in my work.

While experiencing the installation, the audience is exposed to an ambiguous situation in which the behaviours generated do not match any more with those normally associated to a typewriter. The idea of composing open-ended interactions which could elicit multiple meanings influenced the design of the Cembalo Scrivano. This was supported by keeping the original modalities of interaction (i.e. typing) and blocking or contradicting conventional behaviours and interpretations, so as to leave space to the audience to decode the relationships between gestures, language and the audio-visual material. As the sounds and symbols generated do not exactly behave as expected, this approach might be related to the paradoxical strategies for absurd making discussed in Chapter 5.

The tension that might emerge while presenting a typewriter in an art gallery environment, contributes to elicit unexpected interpretations of the object. Gaver et al. refer to this as "ambiguity of context" presenting the pivotal example of the Duchamp's Fountain [141]. Making strange of the typewriter object was another ambition of the project – see the estrangement strategies introduced by the fictional instrument discussed in Chapter 5.

The installation then de-contextualises and re-purposes in a creative and open-ended manner a relatively ordinary object. Within the context of contemporary music, such approach has been pioneered by John Cage with *Imaginary landscape no. 4* for twelve radios. A composition I had the chance to perform in various occasions during my bachelor studies, and which became one of the works that most influenced my undergraduate musical training.

The alteration of the typewriter's functionalities and contexts then aimed to provoke an ambiguous and open-ended experience. From a design viewpoint, this

23 See Donald Glowinski website – last access April 14, 2023

strategy draws on the ideas of "ambiguity as a resource for design" by Gaver et al. [141] and "multiple interpretations" in design practices introduced by Sengers and Gaver [321]. I came across this research thanks to a valuable review I received after having submitted a paper at NIME 2018 which introduced the first version of the Cembalo Scrivano [24]. During that time I was particularly concerned with the problem of combining my artistic and humanistic background with the deterministic and quantitative expectations of the department I just became a member of.

Such critical contributions, as well as the more humanistic HCI sub-communities which they come from, presented me with a viable path for my doctorate. Excited by these discoveries, I adopted them as point of reference for the subsequent developments of the artwork – another example of how communities of practices can shape the technological conceptions and views of their members, see Chapter 3. The HCI debate on ambiguity also resonates with Umberto Eco's essay *Open Work*, which represents another crucial source of influence which shaped the very notion of artwork I sustain in my music technology work [122].

Finally, on a more political level, the artwork is in dialogue with those socio-economical ideologies that impulsively acknowledge the need for new technology, considering the techno-scientific development as the primary *modus operandi* for current and future challenges. The Cembalo Scrivano design approach then poses questions on the narrative of the perpetual advancement and it proposes a *reversed solution* that aims to re-discover the past in order to imagine the future.

This attitude derives from a series of intricate factors related to my personal history, including the cultural background of my family, some years of activism in community centres and my interests in philosophy of technology and social-psychology. To a certain extent, the Cembalo Scrivano project is influenced by the conviction that the notion of *new*, intended as better, more powerful and efficient, should be sometimes replaced by concepts such as reinterpreted, reused and re-generated.

Aesthetic and cultural influences

From a musical viewpoint, the overall character of the installation can be contextualised within the aesthetics values and concerns typical of the electroacoustic

24 Thanks to the same NIME review I also discovered the user-performer paradigm previously introduced.

music tradition. This "compositional bias" relates to the musical conceptions I absorbed during my bachelor and master studies. Electroacoustic music has been the main focus of my artistic work and over the years I developed particular skills and knowledge linked to this practice. As an active electroacoustic musician I also had the chance to be in close touch with specific art and research communities (e.g. computer music institutions) which inevitably contributed to shape my musical sensitivities.

By using the term *electroacoustic* I refer to an aesthetic paradigm which aims to combine acoustic and electronic sounds through a musical language mainly focusing on timbre articulation and energy distribution. In the Western culture, one of the first example of such approach is *Musica su due dimensioni* (1958) [25] composed by Bruno Maderna at the Studio di Fonologia Musicale RAI in Milan. This work had a great impact on my early musical studies, as it is one of the first examples combining an acoustic instrument with the electronic sound. The possibility of a dialogue between the electronic and acoustic dimensions explored by Maderna, is at the core of my musical production and also present in the Cembalo Scrivano. The artwork indeed combines the acoustic sonorities of the typewriter's keys, which are clearly audible while using the machine, with the audio-visual interventions produced by the electronic and digital means.

The aleatory elements of the Cembalo Scrivano previously introduced can also be related to the musical knowledge I absorbed while studying (and practicing) the electroacoustic tradition as well as through my affiliations with music technology departments and experimental music institutions. The use of random and probability-based processes in my work draws on the trajectories laid out by composers and researchers such as Lejaren Hiller, Gottfried Michael Koenig and Iannis Xenakis. As noted in Section 2.1, the musical concepts introduced by these pioneers proved to be rather resilient, and they can be found in many computer systems and workstations of the 1970s, 1980s and 1990s [39]. This can be considered as a clear example of how cultural and material sources might become integrated into individual's backgrounds and, in tandem with personal intuitions and visions, co-constitute subjective perspectives and choices.

25 Maderna composed two versions of this piece which are completely different one from the other. The first version (1952) for flute, percussion and magnetic tape, the second (1958) for flute and magnetic tape. This work can be considered as one of the first composition merging the two main contemporary trends found in Europe at the time: *musique concrète*, focused on the manipulation of given physical phenomena, and *elektronische Musik* concerned with the organisation of musical materials starting from the generation of the single sonic components.

The Cembalo Scrivano was designed with the intention of presenting a participatory performance in which the audience is involved into a creative process. This paradigm, freely inspired by collaborative writing in music practice [93], emerged out the many conversations I had with Fabio Morreale. Fabio's involvement in the project radically influenced the evolution of the work. The continuous exchange of ideas that took place while developing the materials adds a further layer which increases the complexity of my review.

For instance, with Fabio I developed the idea of building a machine that could provide access to an open space through which memories, stories and ideas could be collected and recovered. We then borrowed the metaphor of the book, a media holding information that can be retrieved, to design the interactive experience. Fabio had also great impact on the visual aesthetics of the installation. In this context, his contributions include the design of background graphics, new letter animations, glitch effects as well as the visual implementation of the memory and activity features. Furthermore, we decided to have three different environments (machines, instruments and voices) based on the many and interesting materials he generated while developing and testing new Processing algorithms.

Many aesthetic and technical decisions were instead made because of simple urgency [26]. For instance, while functioning as a stimulus to further develop the artwork, the deadline imposed by the IEM concert also limited the exploration of new interactions.

An example of such inadequate implementations is the "memory" feature, which resulted in the random retrieval previous inputs. This rather basic solution often has no particular effect on the person interacting with the machine. Another example relates to the decision of using samples of voices and instruments for the CS2. This choice was instead made due to the fact that I already had these sample as part of my personal sound bank. I recorded these audio file over the years for different projects I was involved in [27]. This reuse of audio materials provide a further example on how previous experience, situated in different social and cultural contexts, can directly shape the material quality of a new musical artefact.

26 It should be noticed that the Cembalo Scrivano design process has always been characterised by tight time limitations. After the IDMT assignment deadline, I had to work on the installation while also focusing on the progression of my PhD research.

27 For intellectual honesty: played through the Max algorithm designed for the Cembalo Scrivano the samples become rather unrecognisable compared to how they sound in previous projects

Finally, while examining the subjective choices and arrangements made during the development of the interface, it becomes clear that my work has been often conditioned by intuitions that are not explainable in rational and analytical terms. I am not able to define, for instance, the reason why I picked the typewriter out of the many second-hand objects I saw while visiting Deptford Market. However, I can remember the sense of attraction and interest I felt as I spotted the object. Alongside the IDMT assignment, I would acknowledge such *erotic* [28] enchantment as one of the main origins of the Cembalo Scrivano adventure.

Similar unconscious judgments shaped many other aspects of the project in the early stages – including the idea of using audio recordings of the typewriter as the main sonic material of the installation or the decision of rendering a minimal black-and-white layout for the visual elements generated.

My curiosity towards the history of typewriting has been a direct consequence of my fascination for the machine. The media archeology investigation above described began as consequence of such irrational attraction. Out of the many artists I discovered working within a media archeological framework, Gebhard Sengmüller [29] is probably the one that most inspired the Cembalo Scrivano project.

Sengmüller's approach to media archeology often scrutinises alternative futures that did not happen, imagining different ways technologies could have evolved. As an example, in *Slide Movie* he re-invent the cinema by synchronising 24 slide projectors focused on the same screen. As described by the artist: "the formula 'one projector per frame' thus gives rise to something that at least rudimentarily (and inevitably very inaccurately, due to the lack of precision of the mechanical devices) suggests a motion picture" [30].

6.4 DISCUSSION

The narratives sketched explored particular material, subjective and cultural mediations that facilitated the assemblage of Cembalo Scrivano. The following discussion further examines the relational character of these factors, their co-dependency and synergies. I consider how such reciprocity allows to configure the same elements in different ways. In light of different goals and focuses, different associations might help us to better understand the processes behind the composition of a digital musical artefact. The section ends with a few methodological reflections

28 The term *erotic* is here used in reference to its Greek etymology as *something caused by passion*.
29 See Gebhard Sengmüller website – last access April 14, 2023.
30 See the *Slide Movie* webpage for more info – last access April 14, 2023.

on both the first-person analysis introduced and the critical framework developed in this chapter.

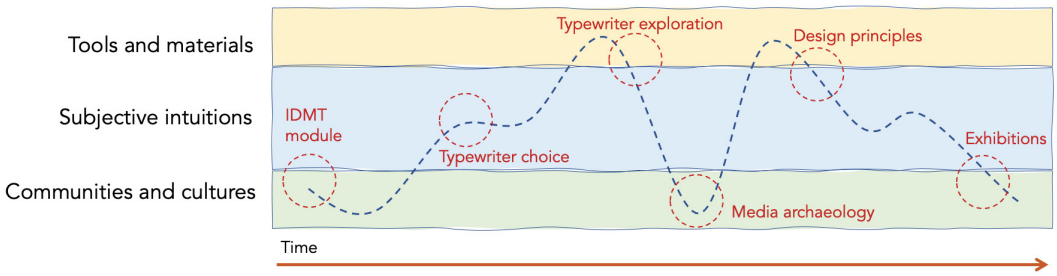
6.4.1 *Holding together different perspectives*

Posing questions on the influence of particular materials, personal backgrounds and cultural contexts helped to examine how specific factors either enabled or restricted the evolution of the artwork. Some elements had great impact on the early stages of the project, the influence of the IDMT module probably being the most obvious example. Some, such as the use of Max and Processing, conditioned the design process throughout longer periods of time. Others instead contributed to specific material and conceptual aspects of the piece – e.g. the discovery of academic contributions on the value of "ambiguity" and "multiplicity" in HCI research or the pivotal suggestions offered by colleagues for the improvement of the key sensing.

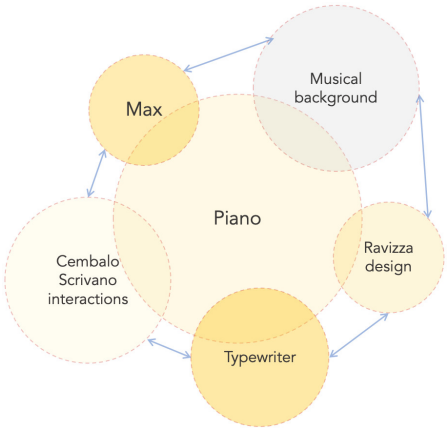
However, while being useful to rationalise possible causes and effects, the elements provided in previous sections are inherently co-dependent. Rather than looking for hierarchical relationships, I wish now to consider how the three dimensions taken into account often co-exist within the same event. The narrative previously introduced indeed reveals a complex network of cross-references where social, material and subjective influence are intertwined.

The forces and tractions produced by these factors can be then interpreted in light of their mutual relations and synergies. To understand even a small portion of the Cembalo Scrivano's genesis means to be able to hold together these interconnected (yet distinguishable) features. The relational view suggested here implies a shift of focus from the particular source of influence to the possible network of associations which enacted the phenomenon under scrutiny. Different correlations might be drawn based on the particular scope of the inquiry and each specific factor might be discussed in relation to its socio-cultural situatedness [34], entanglement with contexts and materials [368, 168] and reciprocity with particular processes and lived experience [303, 307].

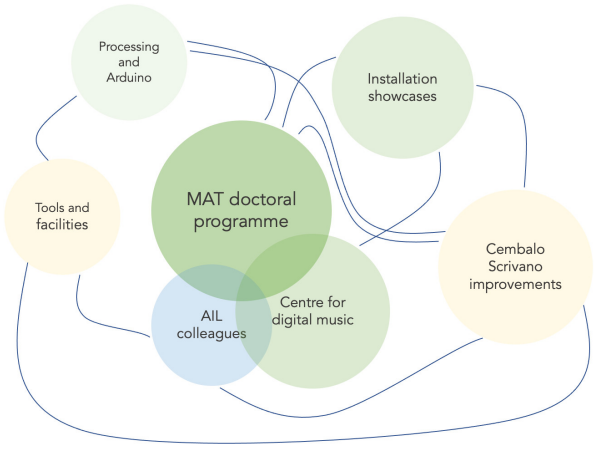
Figure 6.7 aims to loosely evoke the three viewpoints introduced in previous sections, where specific sources are selected and connected in different ways. The three figures are purposively selective, necessary incomplete and, to a certain extent, inaccurate. However, they exemplify how, in view of different focuses and



(a) Subjective timeline



(b) Piano remediation



(c) Influence of communities

Figure 6.7: Three possible configurations of the Cembalo Scrivano's genesis.

outlooks, we can summarise in different ways the first-person account introduced in this chapter.

Figure 6.7a shows a timeline based on my own perspective, highlighting subjective choices and intuitions. Considering the progression of the artwork based my own perspective. According to this view, I started the project due to the assignment of the IDMT module. I then found the typewriter in second-hand market and, fascinated by the object, I started to do some research on its history.

Such material investigation led me to discover the field of media archaeology, and inspired by these cultural studies I developed the conceptual scaffolding of the artwork. I then translated these thoughts into design principles which, along with my artistic background, contributed to the evolution of the interface.

Figure 6.7b outlines a feedback system where the piano is remediated by different elements of the installation. Through this view we might better understand how a given technology is re-interpreted, often traveling from one context to another and influencing the design of new artefacts. The piano is an example of such design migration, where features associated to an existing musical technology are

integrated and negotiated into new contexts – i.e. present in both the original Cembalo Scrivano built by Ravizza and my own interpretation of the device.

The conceptual model behind Max also directly inspired by the piano design – see the discussion in Chapter 4. In this regard, Max's paradigm of event instantiation certainly affected the aesthetic qualities of the installation. As a trained pianist, my instrumental background made me particularly responsive to certain affordances and creative suggestions offered by the typewriter and its ancestor.

Figure 6.7c instead delineates the network of communities and socio-cultural contexts which contributed to the assemblage of the artwork through a complex networks of mediations. The installation has been developed in an academic context, using university resources and facilities, and the support I received from the AIL colleagues largely contributed to the evolution of the installation.

Through these academic communities I had the chance to showcase the Cembalo Scrivano at local and international venues, thus refining the installation for each presentation. While exhibiting the artwork I had the opportunity to interact with different audiences, and the insights gained from such "in situ" observations informed the evolution of the piece. The Cembalo Scrivano has been also affected by the communities that support the tools used in the project (e.g. Arduino and Processing).

6.4.2 *Another evaluation framework?*

While reflecting on the Cembalo Scrivano progressions, I could provide further insights on the ways communities, tools and subjective visions contribute to the assemblage of digital artefact in the contexts of interactive art. It is important to notice that the artwork considered in this chapter was not composed with these three factors in mind. The observations previously introduced are an attempt to retrospectively analyse these elements, exploring how they organically shaped the installation.

The chapter then provides a sort of *illustration of principles*, showing that to ask questions on the influence of contexts, personal background and tools might help to identify tacit factors, making explicit the implicit and acknowledging the complexity of design practices. The critical framework sketched in this chapter might then serve as a template for other researchers to reflect on their practice, and possibly provide them with some useful tools for future adventures.

Nevertheless, there is no intention to propose the analytical structure outlined in this chapter as a possible evaluation framework. NIME literature already offers a variety of contributions on this topic (e.g. [74, 30, 29]), however these works often aspire to a methodological rigour [334] and product management [288] which do not apply to the research presented in this dissertation [31]. Rather, this chapter introduced a critical and open-ended approach for self-reflection which is highly dependent on the practitioner's perspective.

The quality of the researcher's gaze drastically affects the narrative reported. In this regard, we might draw a literary parallel with Queneau's *Exercises in Style* in which the same story, a man getting a bus, is retold 99 times, always with a different style. Similarly, the account introduced in this chapter might promote different degrees of knowledge if conveyed through a bureaucratic or techno-scientific language – although scientists tend prefer numbers to languages.

Alongside goals and focuses, researchers might also consider the modalities through which they convey reflexive discourses as cues that might reveal additional sources of influences. Metaphors, terms and expressions might for instance disclose further cultural and technical references associated to the researcher background. A meta-analysis that might help to critically situate our own perspective and increase awareness.

The analysis provided in this chapter relates to a storytelling attitude, where the main elements are repeated various times. This redundancy can be in part associated to the intention of presenting different tones and nuances, and therefore highlight the complex multiplicity of the vicissitude narrated. On the other hand, prolixity and confusion might derive from the approach to the analysis I took: a sort of free-flowing stream of consciousness, which has been progressively organised.

From a practical point of view, I adopted a top-down approach, thus considering the three areas of enquiry explored in this dissertation and aiming to gather different sources and information that could provide some answers to the research questions posed in Chapter 1.

The research started with a review of the article I published at NIME on the Cembalo Scrivano [227]. Adapting parts of the article for this chapter helped me to identify more specific questions about the underlying elements that influenced the genesis of the piece. These questions lead me to first explore the socio-cultural

31 The considerations presented in this chapter might instead resonate with the phenomenological mindset adopted by Marquez-Borbon for the description of long-term performer-instrument interactions [247].

factors, such as the involvement with the IDMT course and how the various public performances gradually impacted the artwork.

For instance, I searched in my old hard drive the IDMT teaching materials. The revision of slides and assignments' instructions helped me to assess some of implicit values of the module. Another source of information were the emails I exchanged with the organisers of the events where the Cembalo has been presented. This allowed me to better understand how venues requirements and artistic affiliations shaped my work. I could instead reflect on the ways the audience interacted with the installation by looking at the logs of the texts typed in by the users, which I gathered during various performances.

In order to thoroughly consider both technical and aesthetic aspects of the artwork, I also retrieved some of the emails I exchanged with Fabio Morreale while developing the CS2 audio-visual interactions. Once I realised the impact Fabio had on the project I decided to directly contact him to informally interview him to grasp his side of our collaborative experience. Thanks to this exchange I could also recover and review some of the old versions of the CS software I had lost.

Overall, I used to immediately write down, as spare notes, the reflections I developed during these "loose data collections". I then started to organise them following the framework proposed in this thesis and they slowly became the first draft of this chapter. My thoughts on personal and subjective influences (e.g. the influence of my background on the evolution of the artwork) were the last piece needed to complete the analysis. I then attempted to review all the material collected, trying to identify elements linked to my personal artistic and professional journey, and eventually expanding on them.

Fianlly, these processes of generating insights, as well as their discussion, relates to those qualitative research methods in which the data gathering and analysis are simultaneous and interconnected [99, 178]. The character of the narrative here presented also confirm my affiliation with the humanities. Instead of striving to find the most efficient way for communicating results and findings, I privileged a more discursive and open-ended approach that might (hopefully) be perceived and interpreted in different ways. In a nutshell, the research aims to generate ideas rather than categorising reality.

This chapter introduced the Cembalo Scrivano, an augmented typewriter that allows for the real-time generation and manipulation of sonic and visual materials. The project features the re-assemblage of an obsolete technology into an interactive installation. While discussing the evolution of the installation it was possible to apply the ideas and knowledge developed in previous chapters as an analytical framework.

This has been achieved by providing a first-person and practice-based account on the evolution of the artefact, an approach drawing on existing contributions for the critical and self-reflexive scrutiny of technology practices [322, 306]. In line with these approaches, the chapter further explores possible connections between NIME and HCI domains by unpacking the processes behind the design and use of a digital musical artwork [203, 90, 303]. By turning the mirror to myself I had the chance to "test" the practical validity of the work done in previous research. This analytical approach turned out be rather effective to uncover personal aesthetic values and reveal socio-technical influences.

The first-person account presented in this chapter illustrated how material and conceptual features of the technologies used for the design of the installation conditioned its aesthetic outcomes [67, 239]. In line with the findings of Chapter 4 The analysis also examined the migration of design features across different technologies, thus showing how a "new" digital artefact might remediate and re-arrange existing devices [60].

While delineating the different trajectories I drew within particular social groups, I could examine how these cultural contexts facilitated the development of the artwork – e.g. through gradual and differentiated processes of collaboration and assistance [250]. In this regard, it was then possible to illustrate how the contribution of a given community of practice "increases as the apprentice becomes more adept" [218, p. 178]. As considered in Chapter 3, the observations introduced also highlight how shared knowledge and expectations linked to a particular device orient its interpretations and usages.

Various reflections also highlighted how subjective visions and intuitions became inscribed into the design [4]. In particular, my musical background (including previous experience and aesthetic references) affected the interpretation of socio-cultural inputs, the manipulation of materials as well as the creative development of ideas [183]. While outlining the ambiguous and contradictory qualities

of the artwork I was also able to delineate how my own artistic views and musical knowledge contributed to the configuration of the installation – see the findings of Chapter 5.

Overall, the chapter offers a factual and articulated example of the insights and views it is possible to achieve while engaging with the critical framework developed in this thesis; an analytical mindset that can help researchers to increase awareness and transparency over their own values, the patterns suggested by tools and materials as well as the influence of cultural contexts and communities of practices.

7

DISCUSSION

This chapter incorporates material from 'Making Up Instruments: Design Fiction for Value Discovery in Communities of Musical Practice' by Lepri and McPherson originally published in the proceedings of the Designing Interactive Systems Conference, DIS 2019 [225]; 'Embrace the Weirdness: Negotiating Values Inscribed into Music Technology' by Lepri and McPherson, currently under review, to be published in the Computer Music Journal [226] and 'Sonification as Negotiation - Learning from Translation Studies' by Lepri, originally published in the proceedings of the Sound and Music Computing Conference, SMC 2020 [224].

Previous chapters sought to answer questions on the ways subjective, cultural and material factors influence instrument design practices, interpreting these elements as highly inter-dependent. This chapter further develops some of the ideas upholding this thesis in relation to the findings gained through our empirical work. Here, we provide a few conceptual and methodological suggestions that might inform our critical practices, with a focus on the playful discovery of the socio-material processes behind the emergence of DMIs as well as the subjective negotiation of these cultural and technological trends.

7.1 PREMISES

One of the primary aims of our work is to examine how musical values are inscribed to and remediated by DMIs. The research questions presented in Chapter 1 formulated the three focuses of our research, and in doing so they introduced a few assumptions on the ways design practices unfold – assumptions that partially preconfigured the answers sketched in this thesis. We then sought to answer questions addressing subjective, cultural and material factors, interpreting these elements as highly inter-dependent.

Chapter 2 outlined the main references that led us to the conviction that social contexts, digital tools and materials and individual perspectives largely condition the emergence of musical interfaces and interactions. Chapter 3, 5 and 4 illustrated

the approaches we explored to uncover these influences and critically assess them. The retrospective and autobiographical account presented in Chapter 6 showed that, when considering a specific digital artwork, the research questions posed in this dissertation might foster a rich and critical comprehension of situated design processes.

Drawing on the observations advanced with our empirical work, in this chapter we further discuss our research bringing into play some of the research introduced in Chapter 2. In addition, we delineate a few suggestions that might serve as viable conceptual tools for the design and study of digital musical interfaces. In the following pages, these two aspects are often combined as they closely inform each others.

The discussion here proposed might sound rather abstract and therefore distant from the more practical issues linked to technology research [1]. The observations introduced in this section indeed avoid specialised stances and functional design guidelines. Rather, we advance a set of holistic considerations aiming to frame critically the "constellation of mediations" [64] explored in previous chapters.

The concepts introduced in this chapter are then discussed from a broad viewpoint, and they do not engage with the specificity of contexts and uses. This generic view clearly limits the depth of the following sections and it demands further developments and careful reflections based on the particular contexts, musical objectives and design inquiry.

In order to better explain the mindset behind this chapter, we would refer to the distinction made by the ancient Greek culture between *poíesis*, i.e. the production and manipulation of materials based on specific procedures, and *prâxis*: the ability to orient action in view of a given context [2]. According to this perspective, we adopt a broad outlook with the hope to support the *praxes* of others music technologists.

Frauenberger suggests that: "we are not designing computers, nor can we design interactions. What we seem to be doing is creating configurations that enact certain phenomena" [130, p. 12]. We would then argue that, through our practices, we *re-configure* the discourses, representations and materials populating a given socio-cultural context. This chapter outlines a few ways of interpreting elements of such configurations.

1 Although we should be reminded that also math is an abstract construct, without which there would be no technology at all.

2 See the Aristotelian distinction between *poíesis* and *prâxes* [21], and Plato's considerations on the technical and political actions [85].

Flyvbjerg writes of the contrast between the *instrumental rationality* common in technical problem-solving within science and engineering and the *value rationality* provided by the social sciences, which contributes to elucidating "where we are, where we want to go, and what is desirable according to diverse sets of values and interests"[129, p. 167]. In the design of DMIs – and more generally, while developing interactive musical systems – a risk is to jump straight into an instrumental-rational problem space without first considering the underlying system of values driving technological development. In the music-HCI domain, this can take the form of techno-solutionist approaches which devote considerable engineering effort toward the goal of designing tools to enable people to make music, without explicit consideration of what "music" and "instrument" might mean to different communities and individuals.

The speculative work introduced in Chapter 3 gave us a view on how shared representations and values might vary considerably between musicians active in different contexts. Interestingly, the influence of communities and environments often emerged as detached from instrumental practices – see for instance the similar visions found across impro and experimental electronic musicians. Our findings then emphasise the role that different sub-cultures play in shaping the views and goals of practitioners [3].

While considering the academic roots of NIME, various researchers recognised that diverse music technology contexts might promote rather different techno-musical perspectives [250, 149, 274] – which occasionally engender internal epistemological frictions [153, 170, 271]. Drawing on these reflections, our research sought to provide a nuanced view of the different musical perspectives we might encounter while navigating different sub-communities of musical practice, beyond the engineering *versus* composition dichotomy.

Our intention is also to offer a positive reflection on these interdisciplinary challenges. This is mainly motivated by the outcomes of the survey presented in Chapter 3, in which technologists active in SMC and NIME contexts were invited to review a selection of fictional instruments and guess the musical background of the musicians that made them. Our participants exhibited a certain ability to discover the musical values inscribed into the fictional objects and speculate on the cul-

3 On this matter: our empirical work provides a snapshot that might capture a cultural pattern, without uncovering the complex socio-technical and historical processes underlying its formation.

tural affiliations of their creators. We would argue that this expertise might derive from the multidisciplinary "exposure" to which music technologists are regularly subject to.

As examined in Chapter 3 participants often discovered musical backgrounds and genres thanks to knowledge acquired throughout years of involvement in different communities of musical practice. This long-lasting involvement provided them the chance to "resonate" with the views brought in by other musicians. We would frame this ability as a *hermeneutic motion*: an empathic projection grounded in the interpreter's ability to understand diverse musical activities [4].

Similarly, the facilitation and analysis of the fictional workshops and their outcomes required us to temporarily put ourselves in the shoes of the musicians involved in the various studies. This step was crucial to both sustain and encourage participants' speculations and take seriously the intimate and fragile design statements they proposed.

The researcher involved in the discovery of musical values and assumptions linked to particular social settings should nonetheless balance such sympathy with the acknowledgement of the distances that might divide our views from those of others practitioners. An excessive emotional investment might not be beneficial for acknowledging and pondering shared musical assumptions and representations.

In apparent contradiction with the previous lines, we would indeed argue that the discovery of values in contexts also demands a certain degree of detachment. The attitude we are trying to outline then requires the facilitator to attempt the discovery of musical ideas and values without identifying with them or with the musicians / communities that express them. This implies, for instance, an effort to avoid hierarchies or judgments which might be more representative of our own values and assumptions rather than those of the culture we are approaching.

Such condition is certainly utopian when considering our own socio-musical contexts and, more generally, rather difficult to achieve as there will always be subjects and ideas that resonate with our own background and personality more than others. Still, this awareness should not stop us from critically deal with tacit and shared representations. In a nutshell: impartiality as an ideal and unattainable objective to strive for while engaging with the specificity of each musician and her values.

4 By using the metaphor of *motion* we indirectly refer to the concept of *trajectories* that Wenger adopts to describe how participants gradually move towards the centre of a community of practice through peripheral participation and increasing involvement [369] – see Section 2.3.2.

Besides providing valuable resources to better understand musical interfaces as emerging from specific social contexts, the approaches for the discovery of cultural values reported in this dissertation might also be exploited to inform the design of new musical interactions. This prospect poses compelling questions on the ways we *translate* the assumptions we might identify in a given context, and how they inform our design choices. Although this dissertation is essentially concerned with the "mining" of values, rather than their technological exploitation, we wish to sketch a few considerations that might be beneficial to DMI design. More specifically, the following reflections relate to those research practices concerned with the development of technologies addressing the musical conceptions of particular individuals and their communities.

The notion of *hermeneutic motion* [5] previously mentioned draws on George Steiner's examination of the theories of language and translation [332]. Our conviction is that hermeneutics, as a mature corpus of methods concerned with human interpretation, might provide some useful conceptual tools to transfer shared meanings and values into new musical instruments [6]. We do not aim here to suggest a systematic correlation between instrument design and translation studies, our intention is instead to identify a few conceptual elements that might inspire our practices [7].

Interpretation and adaptation studies are concerned with the *transfer* of information across semantic systems and cultural borders [222]. These fields encompass a variety of disciplines, including semiology and philosophy of language, which are clearly out of the scope of our research. Out of this conspicuous body of knowledge, we essentially consider a small set of contributions linked to the work of Umberto Eco [121, 120].

5 Steiner refers to the hermeneutic motion as "the act of elicitation and appropriative transfer of meaning" [332, p. 186].

6 Hermeneutics emerged as field of study linked to the interpretation of biblical and philosophical texts and gradually evolved into a heterogeneous set of theories and approaches for the study of human communication. In particular, nineteenth- and twentieth-century hermeneutics emerged as a theory of understanding (*Verstehen*) through the work of philosophers such as Heidegger, Gadamer and Derrida.

7 Furthermore, we do not wish to establish any direct relations between music and language. As noted by Steiner, considering the practice of organising sounds as a form of language might be inappropriate, because in doing so *"we use [the term] 'language' in a peculiar unstable sense. We may be using it either at the most technical semiotic level (both are 'sequential rule-governed sign system obeying certain constraints') or in a sense almost too large for proper definition (both can communicate human emotions and articulate states of mind')"* [332, p. 445].

The notion of negotiation proposed in Chapter 4 is indeed inspired by Eco's views on translation practices. According to Eco, translation can be framed as a process of mediation in which the translator interacts with the cultures lying behind source and target languages [121]. This view implies that, rather than objectifying a text – e.g. systematically examining it with deductive and qualitative methods – translators imagine themselves inside the cultural system that produced the work and they speculate on the most appropriate ways to convey contents.

Eco then envisions this interpretative process as a negotiation: a dialogue by virtue of which, in order to get something, each party renounces to something else [121]. Such approach relates to the difficulties (and sometimes impossibilities) that characterise translation practices, which should ideally align different languages and cultures. Along with these incompatibilities, Eco acknowledges the limitations linked to the cultural situatedness of the translator who *"moves within a framework of semantic systems that education, culture and history have organised for him"* [121, p. 178].

Inspired by this perspective, we would argue that any attempts to transfer the values we find in a given context into a digital instrument will also partially reflect the designer's values, beliefs, and representations. As discussed in Chapter 4, we might also include into the bargain the musical patterns and ideas linked to the tools and material used to compose the interface.

If we agree on the idea that design practices involve some sort of negotiations, the assemblage of digital musical instruments and interfaces can be viewed as a process entailing different forces which, either tacitly or explicitly, might advance contrasting priorities.

The etymology of the term negotiation merges the Latin roots *nec* - "not" + *otium* - "leisure" or "idleness". From this perspective we can appreciate the dynamic character of this notion: as "negation of not-doing" a negotiation can be understood as an exchange in view of a future synthesis, where the actants involved designate different objectives and support particular routines.

We might then argue that any design attempt to inscribe a formalised musical idea into a technology will inevitably come to terms with the assumptions and representations of the culture from which the idea comes from, the particular views and attitudes of the instrument maker as well as the *grain* of materials and tools used [195]. In short: something will be necessarily lost during the process. The negotiation metaphor might help us to recognise and explicitly acknowledge

the limitations encountered while co-creating the instrument – what is gone, left or hidden and what is actually new.

7.3 EMBRACE THE WEIRDNESS

Previous chapters examined from different and co-dependent perspectives how music technology is embedded with musical knowledge. In particular, we sought to expose some of the musical patterns that popular instrument design tools (e.g. Pd) make more accessible and immediate. Chapter 4, and partially Chapter 6, illustrated how musicians might differently respond to such musical inscriptions based on their backgrounds, socio-cultural belongings and personal visions.

As discussed in Chapter 4, similar findings have been recently reported by various research tackling the latent influence of audio programming languages on the composition of sonic interactions. That complementary results have been achieved using different methods (i.e. wide range ethnographic observation [67] and expert practitioners interview [259]) might be indicative of the depth of the phenomenon under scrutiny.

While reflecting on Pd, we also considered the viewpoint of the language author, who is largely responsible for shaping the scripts and embedded values of the software. Puckette openly acknowledges some of the musical ideas that oriented the design of Pd, suggesting that they inevitably affect the composition of sonic interactions [301].

While reflecting on his work, Puckette declares his intention to "avoid imposing a stylistic bias on the musician's outputs" [300, p. 39] but rather *empowering* a broad community of artists. Nonetheless, he foresees the impossibility of such an honourable attitude: "this reasonable-sounding goal seems always to recede as we try to approach it ... [s]oon we will learn that, no matter how general and powerful we believe today's software to be, it was in fact steeped in tacit assumptions about music making that restrict the field of musical possibility" [301, p. 8].

Building on Puckette's observations, we would argue that, as musical aims are already inscribed into a given technology, a tool defines its possible uses and ends, and not *vice versa*. If the purposes of a technology are nothing other than the possibilities made available by the technology itself [136], technological means can be considered as actual creators of ends [8]. According to this view, we might

8 This connotation seems disruptive in modern society as technology is progressively acquiring the status of *universal mediators* – see Section 2.2. See for instance the well known critique by Morozov

rearrange Machiavelli's motto, from *"the ends justify the means"* to *"the means create ends"*..

With the study presented in Chapter 4 we could then appreciate how, based on Puckette's musical representations and purposes, which he somehow inherited from specific academic contexts, Pd facilitates particular aesthetics and prioritises a small set of recurrent patterns. These influences should not ascribed solely to the mere agency of the language. The communities using and supporting Pd contribute to the production of coding routines which might, for instance, become integrated in the tool's companion materials and indirectly affect individual practices.

From this viewpoint, we overcome the hard distinction between "the technical", "the musical" and "the social" [63] and consider these socio-musical dynamics as crucial parts of the Pd-assemblage – where a piece of software is hardly separable from its communities of practice and authors.

Considering instruments as *proponents of musical ends* – meaning that they reduce the scope of possible uses and, in doing so, they prioritise specific directions – might help us to better frame the musical import of a given DMI. For instance, electronic (analog and digital) pianos have become progressively closer to sound and feel to the acoustic original, yet they still fall short of the original in the eyes of professional musicians. Over the years, the few keyboards that have had a lasting impact on musical culture are not the best emulations, but rather instruments like the Fender Rhodes which present distinctive and sometimes odd qualities which make them *special*; these instruments succeed for what they are (i.e. a unique combination of constrains which provides access to particular results) rather than what they emulate (i.e. as tools designed for the achievement of a given goal).

Similarly, the past decades have seen the appearance of successive generations of hardware and software for designing audio and music systems. Lasting success of any widely-used tool might be partly explained by its distinctive or odd qualities, including its constraints and stylistic assumptions. As with instruments themselves, digital tools for creating instruments are not interesting for the extent to which they approach a mythical ideal of a neutral canvas. Instead, tools might be compelling precisely for their inherent traits and the specific ways in which they influence the thinking of the designer.

We might then reverse the discussion on the stylistic "bias" of music technology and, rather than pursuing neutrality, fidelity or effortless production, we

to technology research and development sectors for too frequently focus on problems that do not exist or provide solutions that nobody asked for [267].

should embrace and even emphasise the wonkiness and weirdness of our tools. In a nutshell: digital music tools not as *tools* but as generators of quirky sonic interactions and routines which largely support pre-existing musical purposes and understandings. Such a mindset, we suggest, might hold benefits in avoiding unrealistic design trajectories, gaining awareness and intimacy with our tools and critically negotiate the aesthetic outcomes of our work.

7.4 THE RECURSIVE PATHS OF DMIS

In Chapter 4 we argued that the musical artefacts designed in our study feature a recursive quality – an idea that strongly relates to the concepts of inscription and (re)mediation introduced in Section 2.2.3. In particular, we intend recursion as a phenomena occurring when something is defined in terms of itself, or of some of its constitutive elements. The instruments created by our participants then tend to repurpose the musical paradigms that Puckette inscribed into his software. Amongst others, the inherent reactiveness of the "piano model" that inspired the design of Pd is also present in many of the sonic interactions composed by participants.

This recursive dynamic, which somehow makes these instruments "extended implementations of the same paradigm" [9], might be better understood in light of Günther Anders's considerations on the anthropological implications of the third industrial revolution [7] [10]. Anders writes about the *ineluctability of technology* to indicate the coercive logic of modern technological development [11]:

> "[T]he possible is generally accepted as the compulsory and what can be done as what must be done. Today's moral imperatives arise from technology and make the moral postulates of our ancestors ridiculous, [..] [n]ot only what can be done must be done, but what must be done is also ineluctable".

Anders's reflection recognises technical thinking as the predominant *ratio essendi* of our time, implying that in the eventuality of a technical possibility its realisa-

9 This expression is used by Puckette to describe the shared nature of Pd and Max – see Chapter 4. The definition seems also to apply to those DMIs that incorporates the Pd software.

10 Unfortunately only a few works by Anders have been translated in to English – see an updated list of Anders's available work in different languages – last access April 14, 2023.

11 The short excerpt here presented, from the introduction of *Die Antiquiertheit des Menschen, vol. II: Über die Zerstörung des Lebens im Zeitalter der dritten industriellen Revolution*, has been translated from the Italian edition [8].

tion is almost inevitable. Anders identifies the design and use of the atomic bomb as emblematic of such anthropological revolution: the potential employment of a techno-scientific knowledge will be, soon or later, implemented, at the expense of any ideological or ethical principle, which inevitably fails to regulate technical courses [12]. *Mutatis mutandi*, in our study we could appreciate a condition according in which the aesthetic intentions and values of our participants were somehow subordinated to the functional needs and instrumental norms induced by the equipment provided. The most clear result of such asymmetry is probably the aesthetic clustering of the sonorities produced by the assembled instruments.

We suggest that the recursive process above mentioned might be partially explained considering what we might call the *executive will* of technical apparatuses. In our case, the *insistence* exhibited by the instruments in accomplishing the musical aims inscribed into one of their main functional elements [13] – e.g. the audio programming language and sensors provided in our compositional game. According to this view, digital instruments translate the working possibilities and objectives of the components that constitute the larger assemblage. Likewise, each element of the system re-purposes a set of musical features which are induced by the functionalities and constrains of their own basic units. In this framework, subjective design choices, which might also negotiate broader cultural influences, contribute to shape digital instruments as they (re)compose some of these recursive *chains*.

With the *quantity affects quality* axiom introduced in Section 2.2, we argued that the extensive amount of techno-musical recursions powering our instruments support the emergence of sonic interactions that are qualitatively uniques. This specificity might be considered as a consequence of the numberless combinations of recursive musical inscriptions present in a given DMI, and it contrasts the idea that digital instruments provide access to an unlimited variety of expressive possibilities or facilitate the reproduction of whatsoever musical notions – whether highly subjective or culturally standardised.

We do not wish to promote a too rigid outlook and we are not denying the role that music technologists play in NIME practices. Instrument designers have

12 The dramatic tone of Anders should be interpreted through his personal history: a german Jew that, after studying with Husserl and Heidegger, migrated to the USA and survived as a factory worker.

13 In light of this observation, it is possible to better understand why Kristina Andersen privileges for her design fiction workshops, mundane materials that, besides not being functional, are not easily associable to music technologies (whether new or traditional). This crucial step allows participants to escape the purposes suggested by functional tools they might have interiorised and open up more individual and imaginative spaces. As cheerfully shouted out by Kristina during a seminar: "An LED wants to blink!" [9].

indeed access to many of the musical inscriptions encoded in digital tools (e.g. Pd's functions and abstractions), and they are able to combine them and manipulate them at various levels, and create a great variety of sonic structures. An attentive analysis of the instruments designed in our game reveals that, within the noise and experimental aesthetic spectrum, musicians configured an assortment of sonic interactions in a limited amount of time.

Still, we seek to emphasise that our tools and materials are not passive objects, but rather are intimately entwined with the creative processes and entangled to the production of new musical knowledge. As pointed out by the work of many researchers (e.g. [70, 156, 239, 157, 240, 331, 274, 194]), the influence of tools and materials can't be ignored.

The idea that digital music tools constrain the work of composers and performers has been widely recognised and even celebrated within music technology research [240, 157, 382]. More generally, that different instruments provide distinct musical resources is an historically grounded notion at the core of many compositional and orchestration attitudes. As noted by Vasquez et al. "[t]he relationship between creation of idiomatic repertoire and the historical development of acoustic instruments is strong and can be traced in time as the former evolves symbiotically depending on the possibilities offered by the later" [355, p. 175].

As outlined in Section 2.1, it is possible to find in the NIME literature various research exploring the notion of *idiomaticity* in relation to DMIs. These include compositional practices [355], the development of idiomatic gestural languages [265, 341] and mapping strategies [40] as well as the examination of the musical patterns facilitated by audio programming languages [259].

In dialogue with these works, we suggest that DMI interactions should be considered as inherently idiomatic. With this we mean that each digital interface support specific sonic outputs and gestures which are therefore tightly bounded with their *media*, to the point that it might be almost impossible to detach them [14].

This condition, as we suggested, is due to the amount of inscriptions DMIs contain, which bind the range of possible musical excursions to a very unique combination of routes. In a way, musical interfaces pre-trace playable passages and musicians, while exploring uncharted fields, are often caught in the itineraries

14 It goes without saying that two interfaces sharing some of their components will most likely facilitate the emergence of similar patterns. From this perspectives fascinating questions arise on the relation between the quantity of inscription and quality of musical interactions. For instance, how much can we modify one of the two digital instrument before starting to appreciate a difference between the two? The work of Jack Armitage offers insightful reflections on this matter [22]

articulated by digital technologies their are engaged with. In this sense the considerations here sketched resonate with Ingold's notion of "wayfinding", whereby "practitioners .. are wanderers, wayfarers, whose skill lies in their ability to find the grain of the world's becoming and to follow its course while bending it to their evolving purpose" [195, p. 92].

7.5 THE VALUE OF SUBJECTIVITY

This research relates to the idea that artists and technologists working with musical interfaces negotiate cultural and technological influences based on individual traits, which comprise their musical backgrounds and design experience. The improbable design strategies introduced in Chapter 5 then sought to promote the emergence of such subjective attitudes. By playing with the "musical absurd" musicians could freely develop peculiar design statements and critical visions which often deviate from the tendencies and routines we might encounter in music technology contexts.

The specificities of the useless artefacts introduced in Chapter 5 are somehow in contrast with the cultural and technological influences considered in previous chapters. Being shared within and between communities, socio-technical trends might indeed flatten the horizon of DMI practices and their creative outcomes. Researchers concerned with the development of interactions for the arts often observe the recurrence of "evergreen" design practices and topics [191]. A quick survey of NIME proceedings might then reveal how specific themes and tools become "fashionable" and are regularly repurposed throughout the years – see the outcomes of the 10,000 Instruments workshop presented in Chapter 5.

As considered in Chapter 4, the aesthetic similarities that often characterise the music made with DMIs might be partially explained by the frequent use of particular technologies (e.g. SuperCollider, Max and Pd). However, the musical stasis we might find in NIME and related academic contexts is a crucial issue that, despite animating many informal post-concert conversations, has not been properly addressed by practitioners [15].

15 It is not our intention to generalise on the broad and varied musical practices concerned with digital technologies. Indeed, within NIME context, there are many valuable artists proposing original and striking music. Still, we would argue that DMIs aesthetics are often polarised around a few particular styles, such as the electroacoustic language or the overly trite (or even idiotic) styles often promoted by digital instruments companies and electronic music cultures.

The affiliations between NIME practitioners and technical departments might be one of the factors contributing to such uniformity. The sectors concerned with technology research heavily rely on a form of thought which privileges the rigour and consistency of formal logic, mathematics and more generally deductive and objectifying methods. Engineering, computer science and related disciplines indeed designate analytical and rational thinking as the eminent research tool. However, pure rationality in itself, as a set of systematic and uniform rules valid for everyone, do not secure any creative import to the design of a musical technologies.

The quantitative approaches we frequently find in music technology research not only tend to exclude subjective musical perceptions but also seem to implicitly encourage "median fit" attitudes or, at the most, their "standard deviations" [16]. As these techno-scientific views largely predominate music technology contexts [170] their influences have broad consequences on the modalities through which practitioners approach artistic practices. In short, the *culture of objectivity*, with its functional and quantitative focus, tends to soften the subjective dimension that diversifies individuals' experience, judgments and behaviours.

Far beyond the analytical and rational outlooks, musicians have access to an immense set of resources for the interpretation and manipulation of musical materials – including embodied, emotional and social abilities. On this note, the cognitive sciences, which currently hold an hegemonic position within academic research, too easily decline the notion of *psyche* developed by the humanities. Since its first steps in the philosophy of Plato, the study of our abilities to perceive and interpret the world indeed combines the rational element with the intuitive, unconscious, manifold and ambiguous components dwelling in each individual [136].

The rhetorical question that we would pose now is: in a context largely governed by rational and technical reasoning, do the conditions still exist for the emergence of a creative and "outlier" thinking which draws on the pre-rational amalgam that permeates and constitutes our individuality? The impression is that the answer would be: less and less. The impractical research presented in Chapter 5 then attempts to contrast the primacy of the objective culture over the subjective one and escape those mechanisms that, far from being solely efficient research methodologies, tends to predict and prescribe musical processes and outcomes.

16 We refer to the those statistical approaches for the description musical practices which estimate patterns conforming to the *normalisation* of data and their *mean values*. These methods inevitably legitimate a *creativity of conformism* in which probabilistic models are at the core of the musical production and musicians become neutral administrators supervising the functioning of a system.

As reviewed in Chapter 2, within HCI and NIME contexts, it is possible to identify a variety of research which share the concerns introduced in this section – including first-person [181, 279, 180], RtD and practice-based research [203, 154, 90]. In particular, we argue that our approach to the discovery of subjective traits and individual perspective might be beneficially adopted in music technology pedagogy. The discussion around NIME education and teaching has grown considerably in recent years, see amongst others [204, 249, 248] [17]. In this context, our impractical work might resonates with the playful and practice-based methods described by Tomás [347] as well as the exploratory and embodied approaches proposed by Hayes [169].

The etymology of the term *education* reveal the two roots *ex* "out of, from" and *ducere* "lead, carry". Such attitude, rooted in the maieutic approach inaugurated by Socrates, is one of the most influential teaching paradigms we can find in the Western history [18]. This didactical perspective implies a dialogical process through which the traits and potentialities of the individuals are recognised and enhanced. The main work of the educator is then to enact (i.e. support the emergence of) the inherent abilities of the person through a relational and inter-subjective attitude.

The approaches for the discovery of subjective qualities and visions surveyed in this thesis (see in particular Chapter 3 and Chapter 5) might be exploited in educational settings as a first approach to DMIs. Intuitively, our research might better fit in design and art contexts where open-ended processes and creative outcomes are usually adopted and valued. However, we would suggest that, with due adjustments, these hazardous explorations might also turn to be advantageous in engineering and computer science environments as they might provide students with critical skills and grow their abilities to find origianl solutions. In this respect, compelling works lie ahead.

7.6 PLAY-MAKE-BELIEVE

As we approach the conclusive stages of this dissertation, it might be opportune to gather a few methodological considerations concerning the studies previously

17 The NIME performance pedagogy workshop hosted at NIME 2021 demonstrates the increasing interest of the community towards educational topics.

18 Another influential paradigm in the Western culture relates to the catechetical tradition, in which knowledgeable adepts *in-form* ("into" + "shape") pupils. To drastically simplify, this approach somehow envisions the learner as an "empty container" in which the teacher puts a given "form". In view of the opposite motions, the terms education and information seem radically incompatible.

presented. The tagline presented in the title of this thesis aims to encapsulate the playful outlook adopted in our research for the scrutiny of music technology practices and assumptions. Additionally, on a second level of interpretation, the terms *play* and *make-believe* relate to the acts of imagining, making and performing questionable and not-yet existing technologies.

In this regard, the cheerful and fictional activities discussed in this dissertation somehow require a *suspension of disbelief* – to use the expression coined by Coleridge. Our research has been indeed conceived to situate musicians and technologists in playful and lighthearted circumstances, which paradoxically, allowed them to take seriously their improbable and speculative work. To better elucidate this peculiar condition we draw attention to Caillois [80], which drawing on Huizinga's *Homo Ludens* [188], suggests that play can be defined as an activity encompassing one or more of the following features [p. 9]:

- *Free*: in which playing is not obligatory; if it were, it would at once lose its attractive and joyous quality as diversion;
- *Separate*: circumscribed within limits of space and time, defined and fixed in advance;
- *Uncertain*: the course of which cannot be determined, nor the result attained beforehand, and some latitude for innovations being left to the player's initiative;
- *Unproductive*: creating neither goods, nor wealth, nor new elements of any kind; and, except for the exchange of property among the players, ending in a situation identical to that prevailing at the beginning of the game;
- *Governed by rules*: under conventions that suspend ordinary laws, and for the moment establish new legislation, which alone counts;
- *Make-believe*: accompanied by a special awareness of a second reality or of a free unreality, as against real life.

To different extents, the above qualities can be linked to the open-ended and make-believe approaches adopted in this thesis. The playful and yet attentive connotations that characterise our work are also in line with Huizinga's understanding of play: "a free activity standing quite consciously outside ordinary life as being 'not serious', but at the same time absorbing the player intensely and utterly" [188, p. 13] – see for instance the attitude we described in Chapter 5 for the making of seriously silly musical interactions.

Similarly, Caillois argues that "all play presupposes the temporary acceptance, if not of an illusion .. then at least of a closed, conventional, and, in certain respects, imaginary universe" [80, p. 19]. Interestingly, the term *illusion* derives from the latin roots *in-ludus*: "in-play", this etymology might help to better appreciate how the act of playing somehow involves the assimilation of an additional and ambiguous appearance. This view then resonates with the studies presented in Chapter 3, in which musicians and technologists were invited to create instruments "as if by magic" and speculate on their hypothetical uses and contexts.

This prospect might inspire a series of reflections on the analogies between the notion of *play* (with the different connotations that the English language offers) and musical practices. However, we focus our reflection on a few methodological elements linked to the imaginative and open-ended attitude embraced in this research.

In order to foster and reinforce fictional stances, our activities often involved a small, yet essential, introductory step which, as a sort of first positive feedback, aims to provide participants with some confidence and trust in the activity. A clear example of this element is the drawing activity described in Chapter 3 which function as a trampoline for the making of magic machines. This relatively simple and achievable task is described in Kristina Andersen's methodology as the *prompt activity* [14]. Within the contexts of the Magic Machines workshop, Andersen makes clear that "[t]he prompt provides a fast, and seemingly random, task that frames the subject of *what we are about to do*, whilst being very easy to execute." [12, p. 41].

Drawing from Andersen, we expanded the prompt approach, shaping it according to the particular requirements of the different studies presented. For instance, while announcing the absurd design challenges, we asked interested participants to send us ideas of unreasonable instruments to be developed during the events. During the hackathon we then proposed to share these ideas during the initial brainstorming session – a move that also favoured a first exchange amongst participants.

Inspired by the artists of Blast Theory, Andersen also frames the prompt activity as a *red spot experience*: "an initial action in a performative experience that indicates whether participants are in or out" [12, p. 41]. Indeed, one of the main advantages of such preparatory step is to provide the researcher with a feeling of people's involvements, so that "it becomes clear if a participant is committed to the process, or will require further support" [ibid]. On this note, it seems important to acknowledge that each participant will cope with the game in different

ways, and the facilitator should suitably stimulate them according to their needs and sensitivities.

This brings us to the crucial role of the facilitator, and the almost theatrical attitude he must undertake to sustain the playful experience. One of the main lessons we have learned by conducting our research is that participants' commitment is directly proportional to the level of engagement of researchers themselves. In short, facilitators must genuinely believe in the performance they orchestrate. Kristina Andersen refers explicitly to the theatrical connotation of her work suggesting that the introductory steps of a Magic Machines workshop aim towards the establishment of a "shared social contract". This agreement between the facilitator and participants is then intended to "mark the beginning of an experience which is out of the ordinary" [12, p. 37]. Moreover, by taking full accountability for what is about to unfold the researcher can actively contributes to the formation of trustful and positive relationships within the group.

Overall, the introduction of new conventions that "suspend ordinary laws" has been the main device we exploited for the emergence of shared and make-believe adventures – see Caillois' account on the nature of play and games above. The notions of *magic* and *absurdity* are two clear examples of the modalities. Such key elements framed and encouraged the making of out-of-ordinary instruments – e.g. beyond the possibilities and standards characterising music technology practices. The collaborative game presented in Chapter 4 also established a set of particular relations amongst participants (as a small game "between us"), which allowed them to get absorbed into the activity without taking it too seriously.

In addition to these make-believe and playful strategies, the activities presented in this thesis have been structured around a few pivotal rules. The first relates to the idea of taking participants through a rapid series of steps which prioritise ideation through making [19]. One of the main reasons behind the choice of designing fast pace activities relates to our need of avoiding overthinking and supporting spontaneous, intuitive and immediate design practices.

Once again, we borrowed this approach from Andersen's work in which participants create fictional artefacts in less than an hour. In this regard, the two-day hackathon differs from the other works which used to last no more than two hours. Still, being a fast-prototyping sprint-design event, our absurd hackathon integrated a rather tight schedule.

19 This procedure can be found in all our research, with the exclusion of the speculative survey introduced in Chapter 3.

The second element that can be found in most of the activities presented in this thesis is the conclusive performance. Musicians and technologists were indeed invited to share their artefacts either by presenting to the group and the end of the activity or by agreeing to make public their work via our documentation. Besides motivating participants, final presentations served as actual deadlines marking the end of the game [20].

Furthermore, we learned that final presentations and performances are extremely valuable moments, in which participants often expand on their work reaching domains that even they had not foreseen in the previous stages of the activity. In this respect, group discussions and comments often function as positive stimuli that helps to further evolve musical and critical reflections.

Our activities often involved additional rules and instructions to those here described – see for instance the absurd workshop *(ir)rationale* presented in Chapter 5. Nonetheless, regardless the particular make-believe settings a researcher might want to explore, we suggest the prompt activity, the fast-pace process and the final performance as extremely valuable devices for the playful discovery of musical values and assumptions.

These elements should be then clearly communicated so as to get all participants on the same chessboard: playing together means to accept the same rules. In this sense, we understood that if followed in strict terms these basic procedures simultaneously anchor participants to a few guidelines and encourage them to freely navigate unusual design spaces. In a way, the open-endedness and creativity that characterised the music technology explorations presented in this dissertation were possible thanks to the presence of these few conventions. As noted by Kristina Andersen: "by setting out the rules of the engagement in a very explicit way, we wanted to minimise the unspoken biasing of a very open set of rules" [12, p. 40].

7.7 SUMMARY OF CONTRIBUTIONS

The work done in this thesis comprises original contributions resulting from six investigations involving more than 100 musicians and technologists. Here, I distill the key contributions of these strands of work before moving to the conclusive

20 It seems important to stress this element since, as noted by Caillois, any game should be limited in time. In our games, the initial steps facilitated by the research represent the starting of the make-believe and the final presentations its end.

reflections.

- *As If By Magic workshop* – In this research musicians active in different musical contexts were invited to imagine and sketch not-yet existing music instruments "as if by magic". The study provided a sense of the range of representations and concerns we might find across the various groups. Our work explored the breadth of possible values and priorities in relation to different music cultures and practices, and by extension some strategies by which values might be queried in other areas of SMC and HCI.

- *Magic Machines survey* – The study relates to an online survey in which music technologists were asked to speculate on the background of the musicians who designed the fictional instruments. This follow-up study gathered further evidences of the presence of shared musical values in the musical prototypes created during the workshop. In particular, it investigated the modalities through which observers with music technology experience identified the background of the musicians involved in the design fiction workshop.

- *Composing Sensors with Pd* – This work explored the ways specific hardware and software technologies influence the design of musical instruments. It presented the outcomes of a compositional game in which music technologists created simple DMIs using common sensors and the Pure Data programming language. Our findings indicate a clustering of stylistic approaches and design patterns associated to the composed instruments. The research then examined how musicians react to musical interactions promoted by the tools and materials provided based on their techno-musical backgrounds and previous experience.

- *Unuseless Music hackathon* – We reported on the outcomes of the *Unuseless Music Design* hackathon, a playful design activity organised around the themes of absurd musical interfaces, questionable sonic interactions and unworkable music designs. The project explored absurd making as a way to support highly subjective, critical and disruptive design practices. The research gave us the opportunity to elicit and make manifest two primary sorts of personal design knowledge: the critique of conventional practices and ideas in music technology research, and the ideation of instruments be-

yond familiar paradigms linked to everyday objects and tools.

- *10.000 Musical Instruments workshop* – we described the *10.000 Musical Instruments for a Semi-Connected World* workshop, a collaborative online event conceived as an unconventional experiment to generate interface ideas and speculate on music technology through open-ended artefacts and playful design explorations. The activity confirmed the potential of absurd making to produce a kind of design visions hooked to the individual makers and embedded into the narratives they participate in. We then showed how this permissive and open-ended attitude allows for the emergence of creative obstructions which question technological assumptions, musical practices as well as the perception of the familiar and the domestic.

- *Practice-based account* – The study applies the reflections advanced in previous chapters as a framework to explore the diverse roots of the artwork. With this intent, a first-person and practice-based account on the evolution of a digital artwork is reported. The composition of the interface is then assessed to uncover cultural and material influences as well as personal design intuitions and judgments. The research highlighted how, while considering in detail a particular design, socio-technical, aesthetic and subjective factors often result inherently interdependent and hardly separable.

7.8 CONCLUSIONS

The reflections outlined in this chapter aim to enhance our ability of interpreting individual and shared assumptions and critically attend to the inscription of values into the interfaces we design. Our inquiry focused on the representations linked to musical instruments. Due to this limited outlook, we do not claim that our findings provide the basis for the resolution of broad epistemological and socio-political issues that characterise music technology domains [170, 271]. Nevertheless, we hope that our creative and practice-based explorations might foster and legitimate the emergence of diverse and unconventional approaches to NIME research.

As pointed by Bjögvinsson et al. "a fundamental challenge for designers and the design community is to move from designing 'things' (objects) to designing Things

(socio-material assemblies)" [47, p. 102]. This dissertation examined our tools and practices within the broader contexts in which we *perform*, viewing the development of a musical instrument as a migration process in which socio-materials features associated with pre-existing musical technologies and contexts are integrated and negotiated into a new assemblage. Based on this attitude, our work then attempted to discover the trails of musical ideas through a set of playful, open-ended and generative strategies.

We discussed digital instruments as highly recursive systems where each component of the interface can be viewed as an active mediator that contributes to define the scopes and possibilities of the assemblage in which it is inscribed. On this point, we shall now advance a few conclusive consideration that might help to better understand our research.

The quest on the *locus of agency* has kept busy scholars and philosophers since a long time. Within the Western culture, the answers to such question broadly vary according the historical context in which they are formulated. From this view point, it is possibly to argue that we do not inhabit the world, but rather the interpretation of the world that the various historical eras provide us [324]. To mention just a few, the ancient world was described by the myth, the Middle Ages considered religion as the only sources of truth, and good's will as the force moving all created things. The scientific view began to emerge in early modern age, and it has been integrated, during the late modern period, with economical, psychological and socio-cultural analyses. In this succession of scenarios it is possible to appreciate how the meaning of things is not entrusted to the things themselves but to their interpretation, which, from time to time, connects them within different systems of significances.

Today, in the age of technological revolutions, the world is essentially disclosed according to its techno-scientific description [21] and agency is often attributed to materials and tools – i.e. to things. Considering things as active agents, which shape both socio-cultural systems and individual cognitions, is indeed a perspective shared by many contemporary theories that, especially in the English and American academic cultures, are becoming increasingly popular. *Posthuman* and

21 On this matter Galimberti provides compelling arguments on the the ways that techno-scientific categories such as efficiency, specialisation and functionality became during the last century anthropological qualities. As noted by Galimberti: "When a carpenter enters a forest he does not see the same things that a poet sees ... [T]echnology provides a *vision of the world* that decides the nature of things and the quality of our gaze ... This is why we say that in its *disposition of the world* and not in its *functionality* must be identified the essence of contemporary technology" [p. 354-355 136, own translation].

new materialism approaches [22] then tend to "decentre the human as the sole source of activity and to elevate the role of the non-human world from a passive backdrop to human activity, to active contributors to relational action as it unfolds" [130, p. 21].

These approaches seem aligned with the trend announced by Marx more than 150 years ago: "[a]ll our invention and progress seem to result in endowing material forces with intellectual life, and in stultifying human life into a material force" [253, p. 656]. In short, the reflections posed in this thesis must be interpreted within the broader cultural and historical context from which they emerge. A context in which the "truth" is that which *works* and where technology provides the conditions for its *production* [136]. Our means then increasingly become "autonomous", not only because, being ends in themselves they exponentially grow in complexity, sophistication and efficacy, but also because, being the primary mediators through which the world is revealed and manipulated, they are inevitably placed at the centre of the philosophical debate, which, every now and then, grants them spiritual life.

Importantly, despite indirectly adopting in some of our reflections the worldview promoted by Posthuman theories, we do not argue for technological determinism. The works presented in this dissertation often highlighted how musician's cultural contexts, personal background and aesthetic outlook can shape the composition of musical interfaces. For instance, in the design fiction activities described in Chapter 3 participants of different musical backgrounds express widely varied musical values through their artefacts. We then call attention to the fact that cultural and aesthetic values might precede, and exist independently from, any specific technology. Even as specific technologies are inscribed with values from their creators [4], musical tools do not themselves necessarily explain the aesthetic values of the community that uses them or from which they comes from.

Still, in the work introduced in Chapter 4, we also suggested that, in the engagement with any musical tool, we should question what patterns it supports, how can we recognise them, and how to account for this influence in the design of our instruments. This led us to discuss digital instruments based on their *idiomaticity* as they often remediate particular pre-existing structures and concepts making

22 Some of the most cited theories linked to these perspectives are Latour's Actor-Network Theory [217], Ihde's Post-Phenomenology [192] and Barad's Agential Realism [28] and Harman's Object-Oriented Ontology [162]. See Frauenberger [130] for a discussion on the implications of these works on HCI research.

easier the emergence of specific musical patterns [341, 259, 355].

Our work gave us the opportunity to appreciate how the discovery of musical values is a delicate and intricate processes where very little can be taken for granted. The strategies here explored then aim to support researchers to acknowledge and meditate the musical assumptions ascribed to musical instruments before committing to any particular approach to technology creation. The discovery exercises we developed are playful explorations which *obstruct* immediate, productive and functional actions. In particular, our work draws from a set of approaches to technology which integrate arts strategies and HCI research [109, 11, 14, 374, 36] based on the idea that "[a] work is created artistically so that its perception is impeded and the greatest possible effect is produced through the slowness of the perception" [328, p. 8].

Rather than jumping straight into the design of musical interactions, we privileged critical and reflexive attitudes to facilitate the emergence of the *underlying grammars* that articulate musicians' attitudes and conducts. We then involved participants in creative and hands-on activities inspired by Kristina Andersen's intuition that "embodied processes facilitate a different form of thinking" [11, p. 630]. These activities can be intended as intermediate steps which resist the impulse of *developing* to support the practice of *noticing* [235]. From a more musical viewpoint, our mindset somehow expands on Alvin Lucier's vision, according to which: "[c]areful listening is more important than making sounds happen" [238].

Previous chapters offered a detailed overview of the advantages of such approach, probably being the most significant the possibility of getting a taste of the subjective features that contribute to the emergence of a musical interface. Alongside this element, the playful and untroubled explorations promoted in our studies remarkably facilitated the challenging tasks of envisioning new musical artefacts. We were indeed surprised by the generative power of the methods explored, both in relation to the level of engagement of our participants and on the basis of the variety and uniqueness of the artefacts created. In this respect, for their richness and depth, the outcomes of our studies often rewarded us with precious insights on the cultural, subjective and technological influences we were investigating.

However, considerable work remains to increase our abilities of querying, in a creative and open-ended fashion, what individuals expect from their instruments, and the role that computing might play within specific musical communities. In particular, we believe that future research might focus on the exploration of music

performance in itself [149], an element that received relatively little consideration in this dissertation. For instance, fictional artefacts might be "acted out" by their creators through the development of *scenarios* which might further aid the emergence of instrumental assumptions and visions [186].

More generally, the co-performance of the instruments developed through the playful explorations presented in this dissertation (or similar) might be an opportunity for critical reflection where researchers come together to explore each other's views and perspective. Music performances, rather than demos and presentations, might then turn to be a viable approach for the discovery of values linked to broader musical communities, including, for instance, audiences, non-professional and amateur musicians or music students.

The autobiographical notes introduced in Chapter 6 illustrate how the critical framework developed in this dissertation generates a type of knowledge that do not relate to the traditional scientific attitude. Indeed, if we follow this conception, in which the researcher is (ideally) a neutral administrator of objective and rigorous principles, to "speak in first person" becomes superfluous, or even disturbing. More generally, our findings and reflections then elude the techno-scientific gaze as they relate to qualities and experience that are not easily measurable.

Not being quantifiable in mathematical terms, our insights do not offer direct opportunities for the implementation and optimisation of DMIs. Likewise the artefacts considered in Chapter 5, all the contributions here suggested are, from a strictly functional point of view, *useless*. In contrast to the attitude that characterises this thesis, the musical contributions we find in academic contests such as NIME, SMC or ICMC, notoriously target the expansion of the technical horizon. Indeed, the work of music technologists often focuses on the development of effective engineering strategies based on the the logic of efficiency – that is to achieve the maximum result with the minimum of means.

Nothing is wrong with this approach in itself, except that it risks becoming a prevailing strand which, privileged by funding bodies concerned with the quantification of research impact, "may obscure other types of fruitful labour" [170, p. 431]. For instance, as our benchmarks essentially relate to the *functioning* of the artwork, it seems that we are loosing the ability to express aesthetic judgments. Based on this perspective, making "useless" research means to explore alternative views to the techno-scientific conceptions and possibly re-discover some of the cultural,

social, musical, aesthetic, subjective and mystical dimensions that are ignored by the scientific investigation.

Overall, the contributions proposed in this dissertation are certainly unusual for research carried within an engineering department. As a matter of fact, this work fails to meet the legitimate expectations of any given specialised field – be it music technology, composition, design, social-psychology, anthropology or musicology. Rather, our work integrates bits from different domains aiming to establish an integrated dialogue between these disciplines. This research might then be particularly useful to those researchers that place themselves outside the self-referentiality of their specialisations – which means to be critical.

The approaches to the discovery of values explored in this thesis support a holistic view that allows us to acknowledge musical perspectives that might be radically different from our own. One of the lessons we learned is that the discovery of differences and particularities should be driven by a sense of curiosity – the latin etymology of the term *curious* relates to the term *care*. This means to try to understand the needs and problems that move practitioners linked to a context that is not ours, and possibly imagine how they might perceive our own field. Our work might then be encapsulated with the following formula: to take care of other's perspectives, outside the specialised dimension by integrating knowledge coming from different domains.

BIBLIOGRAPHY

[1] Marc Abrahams. Improbable research. Online: https://www.improbable.com/ - last access April 14, 2023, 1991 - present.

[2] Michael H. Adler. *The Writing Machine, a History of the Typewriter*. Allen & Unwin, 1973.

[3] Ahmed Ahmed, Steve Benford, and Andy Crabtree. *Digging in the Crates: An Ethnographic Study of DJS' Work*, page 1805–1814. 2012.

[4] Madeleine Akrich. The de-scription of technical objects. In Wiebe E Bijker and John Law, editors, *Shaping technology - Building Society: Studies in Sociotechnical Change*, pages 205–224. MIT Press, Cambridge, 1992.

[5] Philip Alperson. The instrumentality of music. *The Journal of Aesthetics and Art Criticism*, 66(1):37–51, 2008.

[6] Vered Amit. *Realizing Community: Concepts, Social Relationships and Sentiments*. Psychology Press, 2002.

[7] Günther Anders. *Die Antiquiertheit des Menschen: Über die Zerstörung des Lebens im Zeitalter der Dritten Industriellen Revolution*, volume 2. CH Beck, 1980.

[8] Günther Anders. *L'uomo è antiquato II. Sulla distruzione della vita nell'epoca della terza rivoluzione industriale*, volume 2. Bollati Boringhieri, 1992.

[9] Kristina Andersen. Personal communication.

[10] Kristina Andersen. Making magic machines. In *European Academy of Design Conference*, pages 1–11, 2013.

[11] Kristina Andersen. The deliberate cargo cult. In *Proceedings of the Designing Interactive Systems Conference*, page 627–636, 2014.

[12] Kristina Andersen. *Making Magic Machines*. PhD dissertation, KTH, School of Computer Science and Communication, Media Technology and Interaction Design, 2017. URL http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-214017.

[13] Kristina Andersen and Dan Gibson. The instrument as the source of new in new music. *Design Issues*, 33(3):37–55, 2017.

[14] Kristina Andersen and Ron Wakkary. The magic machine workshops: Making personal design knowledge. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, page 1–13, 2019.

[15] Kristina Andersen and Danielle Wilde. Circles and props: making unknown technology. *interactions*, 19(3):60–65, 2012.

[16] Kristina Andersen, Laura Devendorf, James Pierce, Ron Wakkary, and Daniela K Rosner. Disruptive improvisations: Making use of non-deterministic art practices in HCI. In *Extended Abstracts of the Conference on Human Factors in Computing Systems*, page W11, 2018.

[17] Benedict Anderson. *Imagined Communities, Reflections on the Origin and Spread of Nationalism*. Verso, London, 2006.

[18] Leon Anderson. Analytic autoethnography. *Journal of Contemporary Ethnography*, 35(4):373–395, 2006.

[19] Richard C Anderson. Some reflections on the acquisition of knowledge. *Educational Researcher*, 13(9):5–10, 1984.

[20] Mark Applebaum. Pre-composition. Online: https://www.youtube.com/watch?v=Tlx4DK_h8Ws - last access April 14, 2023, 2003.

[21] Aristotle. *The Nicomachean Ethics*. Penguin, 2004.

[22] Jack Armitage. *Subtlety and Detail in Digital Musical Instrument Design*. PhD thesis, Queen Mary University of London, 2021 - forthcoming.

[23] Jack Armitage and Andrew McPherson. The stenophone: live coding on a chorded keyboard with continuous control. In *Proceedings of the International Conference on Live Coding*, 2017.

[24] Jack Armitage, Fabio Morreale, and Andrew McPherson. The finer the musician, the smaller the details: Nimecraft under the microscope. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 393–398, 2017. URL http://www.nime.org/proceedings/2017/nime2017_paper0074.pdf.

[25] Kristin Asdal, Brita Brenna, and Ingunn Moser. *Technoscience - The politics of interventions*. 2007.

[26] Joseph Auner. Making old machines speak: images of technology in recent music. *ECHO: a Music-centered Journal*, 2(2):2, 2000.

[27] Seyram Avle, Silvia Lindtner, and Kaiton Williams. How methods make designers. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 472–483, 2017.

[28] Karen Barad. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Duke University Press, 2007.

[29] Jerônimo Barbosa, Filipe Calegario, Verônica Teichrieb, Geber Ramalho, and Patrick McGlynn. Considering audience's view towards an evaluation methodology for digital musical instruments. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2012. URL http://www.nime.org/proceedings/2012/nime2012_174.pdf.

[30] Jeronimo Barbosa, Joseph Malloch, Marcelo Wanderley, and Stéphane Huot. What does 'evaluation' mean for the NIME community? In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 156–161, 2015. URL http://www.nime.org/proceedings/2015/nime2015_301.pdf.

[31] Jeffrey Bardzell, Shaowen Bardzell, and Mark A Blythe. *Critical Theory and Interaction Design*. MIT Press, 2018.

[32] Shaowen Bardzell and Jeffrey Bardzell. Towards a feminist HCI methodology: Social science, feminism, and HCI. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 675–684, 2011.

[33] Frederic Bartlett. *Thinking: An experimental and Social Study.* Basic Books, 1958.

[34] Eliot Bates. The social life of musical instruments. *Ethnomusicology*, 56(3): 363–395, 2012.

[35] Eric P.S. Baumer and M. Six Silberman. When the implication is not to design (technology). In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, page 2271–2274, 2011.

[36] Genevieve Bell, Mark Blythe, and Phoebe Sengers. Making by making strange: Defamiliarization and the design of domestic technologies. *Transactions on Computer-Human Interaction*, 12(2):149–173, 2005.

[37] Steve Benford, Peter Tolmie, Ahmed Y Ahmed, Andy Crabtree, and Tom Rodden. Supporting traditional music-making: designing for situated discretion. In *Proceedings of the Conference on Computer Supported Cooperative Work*, pages 127–136. ACM, 2012.

[38] Steve Benford, Adrian Hazzard, Alan Chamberlain, Kevin Glover, Chris Greenhalgh, Liming Xu, Michaela Hoare, and Dimitrios Darzentas. Accountable artefacts: the case of the carolan guitar. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 1163–1175, 2016.

[39] Paul Berg. Abstracting the future: The search for musical constructs. *Computer Music Journal*, 20(3):24–27, 1996.

[40] Michael Berger. The grip maestro : Idiomatic mappings of emotive gestures for control of live electroacoustic music. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 419–422, Sydney, Australia, 2010. URL http://www.nime.org/proceedings/2010/nime2010_419.pdf.

[41] Peter Ludwig Berger and Thomas Luckmann. *The Social Construction of Reality: A Treatise in the Sociology of Knowledge*. Anchor, 1966.

[42] Wiebe E Bijker, Thomas P Hughes, and J Trevor. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press, 1987.

[43] Karin Bijsterveld and Marten Schulp. Breaking into a world of perfection: Innovation in today's classical musical instruments. *Social Studies of Science*, 34(5):649–674, 2004.

[44] Stephen Billett. Situated learning: Bridging sociocultural and cognitive theorising. *Learning and Instruction*, 6(3):263–280, 1996.

[45] S. M. Astrid Bin. Discourse is critical: Towards a collaborative NIME history. In *Proceedings of the Conference on New Interfaces for Musical Expression*, 2021 - forthcoming.

[46] S.M. Astrid Bin. *The Show Must Go Wrong: Towards an Understanding of Audience Perception of Error in Digital Musical Instrument Performance*. PhD thesis, Queen Mary University of London, 2018.

[47] Erling Bjögvinsson, Pelle Ehn, and Per-Anders Hillgren. Design things and design thinking: Contemporary participatory design challenges. *Design Issues*, 28(3):101–116, 2012.

[48] Erling Björgvinsson, Pelle Ehn, and Per-Anders Hillgren. Participatory design and democratizing innovation. In *Proceedings of the Biennial Participatory Design Conference*, pages 41–50, 2010.

[49] Julian Bleecker. Design fiction: A short essay on design, science, fact and fiction. *Near Future Laboratory*, 29, 2009.

[50] Eli Blevis. Sustainable interaction design: Invention & disposal, renewal & reuse. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 503–512, 2007.

[51] Herbert Blumer. *Symbolic Interactionism: Perspective and Method*. University of California Press, 1986.

[52] Mark Blythe. Research through design fiction: Narrative in real and imaginary abstracts. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, page 703–712, 2014.

[53] Mark Blythe and Enrique Encinas. The co-ordinates of design fiction: Extrapolation, irony, ambiguity and magic. In *Proceedings of the GROUP International Conference on Supporting Group Work*, pages 345–354. ACM, 2016.

[54] Mark Blythe and Andrew Monk. *Funology 2: from Usability to Enjoyment*. Springer, 2018.

[55] Mark Blythe, Kristina Andersen, Rachel Clarke, and Peter Wright. Anti-solutionist strategies: Seriously silly design fiction. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 4968–4978, 2016.

[56] Mark A Blythe and Peter C Wright. Pastiche scenarios: Fiction as a resource for user centred design. *Interacting with Computers*, 18(5):1139–1164, 2006.

[57] Margaret A Boden. *The creative mind: Myths and mechanisms*. Routledge, 2004.

[58] Susanne Bødker. When second wave HCI meets third wave challenges. In *Proceedings of the Nordic Conference on Human-computer Interaction*, pages 1–8, 2006.

[59] Susanne Bødker. Third-wave HCI, 10 years later—participation and sharing. *interactions*, 22(5):24–31, 2015.

[60] J David Bolter and Richard A Grusin. *Remediation: Understanding New Media*. MIT Press, 1999.

[61] Georgina Born. *Rationalizing Culture: IRCAM, Boulez, and the Institutionalization of the Musical Avant-garde*. University of California Press, 1995.

[62] Georgina Born. On musical mediation: Ontology, technology and creativity. *Twentieth-century music*, 2(1):7–36, 2005.

[63] Georgina Born. For a relational musicology: Music and interdisciplinarity, beyond the practice turn: The 2007 dent medal address. *Journal of the Royal Musical Association*, 135(2):205–243, 2010.

[64] Georgina Born. Music and the materialization of identities. *Journal of Material Culture*, 16(4):376–388, 2011.

[65] Georgina Born and Andrew Barry. Music, mediation theories and actor-network theory. *Contemporary Music Review,*, pages 443–487, 2018.

[66] Georgina Born and Kyle Devine. Music technology, gender, and class: Digitization, educational and social change in britain. *Twentieth-Century Music*, pages 135–172, 2015.

[67] Georgina Born and Joe Snape. Max, music software, and the mutual mediation of aesthetics and digital technologies. In Georgina Born, editor, *Music and Digital Media: A Planetary Anthropology*. Durham, NC: Duke University Press, forthcoming.

[68] Alan Borning and Michael Muller. Next steps for value sensitive design. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, page 1125–1134, 2012.

[69] John Bowers. The logic of annotated portfolios: Communicating the value of research through design'. In *Proceedings of the Designing Interactive Systems Conference*, pages 68–77, 2012.

[70] John Bowers and Phil Archer. Not hyper, not meta, not cyber but infra-instruments. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 5–10, 2005. URL http://www.nime.org/proceedings/2005/nime2005_005.pdf.

[71] John Bowers and Owen Green. All the noises: Hijacking listening machines for performative research. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 114–119, 2018. URL http://www.nime.org/proceedings/2018/nime2018_paper0026.pdf.

[72] John Bowers, John Richards, Tim Shaw, Jim Frieze, Ben Freeth, Sam Topley, Neal Spowage, Steve Jones, Amit Patel, and Li Rui. One knob to rule them all: Reductionist interfaces for expansionist research. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 433–438, 2016. URL http://www.nime.org/proceedings/2016/nime2016_paper0085.pdf.

[73] Brian Boyd. Laughter and literature: A play theory of humor. *Philosophy and Literature*, 28(1):1–22, 2004.

[74] Dom Brown, Chris Nash, and Tom Mitchell. A user experience review of music interaction evaluations. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 370–375, 2017. URL http://www.nime.org/proceedings/2017/nime2017_paper0070.pdf.

[75] John Seely Brown, Allan Collins, and Paul Duguid. Situated cognition and the culture of learning. *Educational researcher*, 18(1):32–42, 1989.

[76] Nick Bryan-Kinns and Li Zijin. Reimagining: Cross-cultural co-creation of a chinese traditional musical instrument with digital technologies. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 382–387, 2020. URL https://www.nime.org/proceedings/2020/nime2020_paper75.pdf.

[77] Alan Bryman. *Social Research Methods*. Oxford university press, 2014.

[78] David Burrows. Instrumentalities. *The Journal of Musicology*, 5(1):117–125, 1987.

[79] Claude Cadoz. Supra-instrumental interactions and gestures. *Journal of New Music Research*, 38(3):215–230, 2009.

[80] Roger Caillois. *Man, Play, and Games*. University of Illinois Press, 1961.

[81] Filipe Calegario. *Designing Digital Musical Instruments Using Probatio: A Physical Prototyping Toolkit*. Springer, 2019.

[82] Filipe Calegario, Marcelo M Wanderley, Stéphane Huot, Giordano Cabral, and Geber Ramalho. A method and toolkit for digital musical instruments: Generating ideas and prototypes. *IEEE MultiMedia*, 24(1):63–71, 2017.

[83] Ewa Callahan. Interface design and culture. *Annual review of information science and technology*, 39(1):255–310, 2005.

[84] Michel Callon. Society in the making: the study of technology as a tool for sociological analysis. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, pages 83–103, 1987.

[85] Giuseppe Cambiano. *Platone e le Tecniche*. Einaudi, 1971.

[86] Antonio Camurri, Shuji Hashimoto, Matteo Ricchetti, Andrea Ricci, Kenji Suzuki, Riccardo Trocca, and Gualtiero Volpe. Eyesweb: Toward gesture and affect recognition in interactive dance and music systems. *Computer Music Journal*, 24(1):57–69, 2000.

[87] Caroline Cance, Hugues Genevois, and Danièle Dubois. What is instrumentality in new digital msuical devices? A contribution from cognitive linguistics and psychology. *Computing Research Repository*, 2009.

[88] Carlos E Cancino-Chacón, Maarten Grachten, Werner Goebl, and Gerhard Widmer. Computational models of expressive music performance: A comprehensive and critical review. *Frontiers in Digital Humanities*, 5:25, 2018.

[89] Jacques Carelman. *Catalogue of Extraordinary Objects*. Abelard-Schuman, London, 1971.

[90] Benjamin Carey and Andrew Johnston. Reflection on action in NIME research: Two complementary perspectives. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 377–382, 2016. URL http://www.nime.org/proceedings/2016/nime2016_paper0075.pdf.

[91] Kim Cascone. The aesthetics of failure: 'post-digital' tendencies in contemporary computer music. *Computer Music Journal*, 24(4):12–18, 2000.

[92] Joel Chadabe. Interactive composing: An overview. *Computer Music Journal*, 8(1):22–27, 1984.

[93] Alessandro Cipriani, Fabio Cifariello Ciardi, Luigi Ceccarelli, and Mauro Cardi. Collective composition: the case of edison studio. *Organised Sound*, 9 (3):261–270, 2004.

[94] Jace Clayton. *Uproot: Travels in 21st-century music and digital culture*. FSG Originals, 2016.

[95] Anthony P Cohen. *Symbolic Construction of Community*. Routledge, 2013.

[96] Nicholas M Collins. *Towards Autonomous Agents for Live Computer Music: Realtime Machine Listening and Interactive Music Systems*. PhD thesis, University of Cambridge, 2007.

[97] Perry R. Cook. Principles for designing computer music controllers. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 3–6, 2001. URL http://www.nime.org/proceedings/2001/nime2001_003.pdf.

[98] Tim Cooper. Durable consumption: reflections on product life cycles and the throwaway society. In E. Hertwich, editor, *Proceedings of Lifecycle Approaches to Sustainable Consumption Workshop*, pages 11–27, 2002.

[99] Juliet M Corbin and Anselm Strauss. Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative sociology*, 13(1):3–21, 1990.

[100] Andrew Cox. What are communities of practice? a comparative review of four seminal works. *Journal of Information Science*, 31(6):527–540, 2005.

[101] Phebe Cramer. *Protecting the Self: Defense Mechanisms in Action*. Guilford Press, 2006.

[102] Alexei Czeskis, Ivayla Dermendjieva, Hussein Yapit, Alan Borning, Batya Friedman, Brian Gill, and Tadayoshi Kohno. Parenting from the pocket: Value tensions and technical directions for secure and private parent-teen mobile safety. In *Proceedings of the Symposium on Usable Privacy and Security*, page 15. ACM, 2010.

[103] Peter Dalsgaard and Lone Koefoed Hansen. Performing perception—staging aesthetics of interaction. *Transactions on Computer-Human Interaction*, 15(3):1–33, 2008.

[104] Jonathan De Souza. *Music at Hand: Instruments, Bodies, and Cognition*. Oxford University Press, 2017.

[105] Jessica T DeCuir-Gunby, Patricia L Marshall, and Allison W McCulloch. Developing and using a codebook for the analysis of interview data: An example from a professional development research project. *Field methods*, 23(2): 136–155, 2011.

[106] Elisa M Del Galdo. Culture and design. In *International Users Interface*, pages 74–87. John Wiley & Sons, Inc., 1996.

[107] Joanna Demers. *Listening through the noise: the aesthetics of experimental electronic music*. Oxford University Press, 2010.

[108] Audrey Desjardins and Aubree Ball. Revealing tensions in autobiographical design in HCI. In *Proceedings of the Designing Interactive Systems Conference*, page 753–764, 2018.

[109] Laura Devendorf, Kristina Andersen, Daniela K Rosner, Ron Wakkary, and James Pierce. From HCI to HCI-amusement: Strategies for engaging what new technology makes old. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, page 1–12, 2019.

[110] Kristin N Dew and Daniela K Rosner. Lessons from the woodshop: Cultivating design with living materials. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 1–12, 2018.

[111] J Dewey. *Human Nature and Conduct*. Henry Holt and Company, 1922.

[112] Carl DiSalvo, Andrew Clement, and Volkmar Pipek. Communities: Participatory design for, with and by communities. In *Routledge International Handbook of Participatory Design*, pages 202–230. Routledge, 2012.

[113] Christopher Dobrian and Daniel Koppelman. The 'E' in NIME: musical expression with new computer interfaces. In *Proceedings of the Conference on New Interfaces for Musical Expression*, pages 277–282. IRCAM—Centre Pompidou, 2006.

[114] Mine Dogantan-Dack. *Artistic Practice as Research in Music: Theory, Criticism, Practice*. Routledge, 2016.

[115] Emily Dolan. Toward a musicology of interfaces. *Keyboard Perspectives*, 5: 1–12, 2012.

[116] Paul Dourish. *Where the Action Is: the Foundations of Embodied Interaction*. MIT press, 2004.

[117] Paul Dourish. Implications for design. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 541–550, 2006.

[118] Anthony Dunne and Fiona Raby. *Speculative Everything: Design, Fiction, and Social Dreaming*. MIT press, 2013.

[119] Émile Durkheim. Représentations individuelles et représentations collectives. *Revue de Métaphysique et de Morale*, 6(3):273–302, 1898.

[120] Umberto Eco. *The Limits of Interpretation*. Indiana University Press, 1994.

[121] Umberto Eco. *Mouse or Rat?: Translation as Negotiation*. Hachette, 2013.

[122] Umberto Eco et al. *The Open Work*. Harvard University Press, 1989.

[123] Michael Edwards. Algorithmic composition: computational thinking in music. *Communications of the ACM*, 54(7):58–67, 2011.

[124] Ludvig Elblaus. *Crafting Experience: Designing Digital Musical Instruments for Long-Term Use in Artistic Practice*. PhD thesis, KTH Royal Institute of Technology, 2018.

[125] Georg Essl and Sile O'modhrain. An enactive approach to the design of new tangible musical instruments. *Organised sound*, 11(3):285–296, 2006.

[126] Andrew Feenberg. *Transforming Technology: a Critical Theory Revisited*. Oxford University Press, 2002.

[127] Rebecca Fiebrink. Machine learning as meta-instrument: Human-machine partnerships shaping expressive instrumental creation. In *Musical Instruments in the 21st Century*, pages 137–151. Springer, 2017.

[128] Rebecca Fiebrink and Laetitia Sonami. Reflections on eight years of instrument creation with machine learning. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 237–242, 2020. URL https://www.nime.org/proceedings/2020/nime2020_paper45.pdf.

[129] Bent Flyvbjerg. *Making Social Science Matter: Why Social Inquiry Fails and How It Can Succeed Again*. Cambridge university press, 2001.

[130] Christopher Frauenberger. Entanglement HCI the next wave? *Transactions on Computer-Human Interaction*, 27(1), 2019.

[131] Emma Frid. Accessible digital musical instruments—a review of musical interfaces in inclusive music practice. *Multimodal Technologies and Interaction*, 3(3):57, 2019.

[132] Batya Friedman. Value-sensitive design. *interactions*, 3(6):16–23, 1996.

[133] Batya Friedman and Peter H Kahn Jr. Human values, ethics, and design. In *The Human-Computer Interaction Handbook*, pages 1223–1248. CRC Press, 2007.

[134] Batya Friedman, Peter H Kahn, and Alan Borning. Value sensitive design and information systems. *The Handbook of Information and Computer Ethics*, pages 69–101, 2008.

[135] Batya Friedman, David G Hendry, Alan Borning, et al. A survey of value sensitive design methods. *Foundations and Trends® in Human–Computer Interaction*, 11(2):63–125, 2017.

[136] Umberto Galimberti. *Psiche e Techne: l'Uomo nell'Età della Tecnica*. Feltrinelli Editore, 2002.

[137] Bill Gaver, Tony Dunne, and Elena Pacenti. Cultural probes. *interactions*, 6 (1):21–29, 1999.

[138] William Gaver. Making spaces: how design workbooks work. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 1551–1560. ACM, 2011.

[139] William Gaver. Making spaces: How design workbooks work. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, page 1551–1560, 2011.

[140] William Gaver. What should we expect from research through design? In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 937–946, 2012.

[141] William W Gaver, Jacob Beaver, and Steve Benford. Ambiguity as a resource for design. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 233–240, 2003.

[142] Silvia Gherardi, Davide Nicolini, and Francesca Odella. Toward a social understanding of how people learn in organizations: The notion of situated curriculum. *Management Learning*, 29(3):273–297, 1998.

[143] James J Gibson. *The ecological approach to visual perception*. Houghton Mifflin, 1979.

[144] Erving Goffman. *Frame Analysis: An Essay on the Organization of Experience*. Harvard University Press, 1974.

[145] Visda Goudarzi, Artemis Gioti, Giacomo Lepri, and Fabio Morreale. Exploring participatory sound art. In *Proceedings of the International Computer Music Conference*, 2019.

[146] Owen Green. Agility and playfulness: Technology and skill in the performance ecosystem. *Organised Sound*, 16(2):134–144, 2011.

[147] Owen Green. Audible ecosystemics as artefactual assemblages: Thoughts on making and knowing prompted by practical investigation of di scipio's work. *Contemporary Music Review*, 33(1):59–70, 2014.

[148] Owen Green. NIME, musicality and practice-led methods. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 1–6, 2014. URL http://www.nime.org/proceedings/2007/nime2007_106.pdf.

[149] Owen Green. The situation of practice-led research around nime, and two methodological suggestions for improved communication. *Leonardo*, 49(1): 78–79, 2016.

[150] Betsy Greer. *Knitting for Good!: A Guide to Creating Personal, Social, and Political Change Stitch by Stitch*. Shambhala Publications, 2008.

[151] Richard Grusin. Radical mediation. *Critical Inquiry*, 42(1):124–148, 2015.

[152] Michael Gurevich. Methodology soup: Diversity in NIME research practices. In *Presented at the NIME 2014 Practice-Based Research Workshop*, 2014.

[153] Michael Gurevich. Diversity in NIME research practices. *Leonardo*, 49(1): 80–81, 2016.

[154] Michael Gurevich. Discovering instruments in scores: A repertoire-driven approach to designing new interfaces for musical expression. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages

163–168, 2017. URL http://www.nime.org/proceedings/2017/nime2017_paper0031.pdf.

[155] Michael Gurevich and A Cavan Fyans. Digital musical interactions: Performer–system relationships and their perception by spectators. *Organised Sound*, 16(2):166–175, 2011.

[156] Michael Gurevich and Jeffrey Treviño. Expression and its discontents : Toward an ecology of musical creation. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 106–111, 2007. URL http://www.nime.org/proceedings/2007/nime2007_106.pdf.

[157] Michael Gurevich, Paul Stapleton, and Adnan Marquez-Borbon. Style and constraint in electronic musical instruments. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 106–111, 2010. URL http://www.nime.org/proceedings/2010/nime2010_106.pdf.

[158] Robert H Jack. *Tangibility and Richness in Digital Musical Instrument Design*. PhD thesis, Queen Mary University of London, 2019.

[159] Stefan Haefliger, Georg Von Krogh, and Sebastian Spaeth. Code reuse in open source software. *Management Science*, 54(1):180–193, 2008.

[160] Donna Haraway. Situated knowledges: The science question in feminism and the privilege of partial perspective. *Feminist Studies*, 14(3):575–599, 1988.

[161] Sarah-Indriyati Hardjowirogo. Instrumentality. on the construction of instrumental identity. In *Musical Instruments in the 21st Century*, pages 9–24. Springer, 2017.

[162] Graham Harman. *Object-oriented ontology: A new theory of everything*. Penguin UK, 2018.

[163] Jacob Harrison, Robert H Jack, Fabio Morreale, and Andrew P. McPherson. When is a guitar not a guitar? cultural form, input modality and expertise. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 299–304, 2018. URL http://www.nime.org/proceedings/2018/nime2018_paper0063.pdf.

[164] Steve Harrison, Deborah Tatar, and Phoebe Sengers. The three paradigms of HCI. In *Alt. CHI Session at the CHI Conference on human factors in computing systems San Jose, California, USA*, pages 1–18, 2007.

[165] Steve Harrison, Phoebe Sengers, and Deborah Tatar. Making epistemological trouble: Third-paradigm HCI as successor science. *Interacting with computers*, 23(5):385–392, 2011.

[166] Sabrina Hauser, Doenja Oogjes, Ron Wakkary, and Peter-Paul Verbeek. An annotated portfolio on doing postphenomenology through research products. In *Proceedings of the Designing Interactive Systems Conference*, pages 459–471, 2018.

[167] Lauren Hayes. Enacting musical worlds: Common approaches to using NIMEs within both performance and person-centred arts practices. In Edgar Berdahl and Jesse Allison, editors, *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 299–302, 2015. URL http://www.nime.org/proceedings/2015/nime2015_227.pdf.

[168] Lauren Hayes. From site-specific to site-responsive: Sound art performances as participatory milieu. *Organised Sound*, 22(1):83, 2017.

[169] Lauren Hayes. Sound, electronics, and music: A radical and hopeful experiment in early music education. *Computer Music Journal*, 41(3):36–49, 2017.

[170] Lauren Hayes and Adnan Marquez-Borbon. Nuanced and interrelated mediations and exigencies (NIME): Addressing the prevailing political and epistemological crises. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 428–433, 2020. URL https://www.nime.org/proceedings/2020/nime2020_paper83.pdf.

[171] N Katherine Hayles. *How We Think: Digital Media and Contemporary Technogenesis*. University of Chicago Press, 2012.

[172] Thomas N Headland, Kenneth L Pike, and Marvin Harris. Emics and etics: The insider/outsider debate. In *Frontiers of Anthropology*, volume 7. Sage Publications, Inc, 1990.

[173] Georg Wilhelm Friedrich Hegel. *The Science of Logic*, volume II. New York: Humanities Press, 1969. Trans. A.V. Miller.

[174] Georg Wilhelm Friedrich Hegel. *Hegel's Logic*. Oxford University Press Oxford, 1975. Trans. W. Wallace - Part I of Hegel's *Encyclopaedia of the Philosophical Sciences*.

[175] Antoine Hennion. Music and mediation: Towards a new sociology of music. *The Cultural Study of Music: A Critical Introduction*, pages 80–91, 2003.

[176] Garnet Hertz and Jussi Parikka. Zombie Media: Circuit bending media archaeology into an art method. *Leonardo*, 45(5):424–430, 2012.

[177] Nancy L Hoft. Developing a cultural model. In *International Users Interface*, pages 41–73. John Wiley & Sons, Inc., 1996.

[178] Judith A Holton. Qualitative tussles in undertaking a grounded theory study. *The Grounded Theory Review*, 8(3):37–49, 2009.

[179] Derek Holzer, Henrik Frisk, and Andre Holzapfel. Sounds of futures passed: Media archaeology and design fiction as a NIME methodologies. In *Proceedings of the Conference on New Interfaces for Musical Expression*, 2021 - forthcoming.

[180] Sarah Homewood, Amanda Karlsson, and Anna Vallgårda. *Removal as a Method: A Fourth Wave HCI Approach to Understanding the Experience of Self-Tracking*, page 1779–1791. 2020.

[181] Kristina Höök. Transferring qualities from horseback riding to design. In *Proceedings of the 6th Nordic Conference on Human-Computer Interaction*, page 226–235, 2010.

[182] Kristina Höök. *Designing with the Body: Somaesthetic Interaction Design*. MIT Press, 2018.

[183] Kristina Höök, Baptiste Caramiaux, Cumhur Erkut, Jodi Forlizzi, Nassrin Hajinejad, Michael Haller, Caroline Hummels, Katherine Isbister, Martin Jonsson, George Khut, et al. Embracing first-person perspectives in soma-based design. In *Informatics*, volume 5, page 8, 2018.

[184] Michael S Horn. The role of cultural forms in tangible interaction design. In *Proceedings of the Conference on Tangible, Embedded and Embodied Interaction*, pages 117–124. ACM, 2013.

[185] Eva Hornecker. Beyond affordance: Tangibles' hybrid nature. In *Proceedings of the Conference on Tangible, Embedded and Embodied Interaction*, pages 175–182, 2012.

[186] Steve Howard, Jennie Carroll, John Murphy, and Jane Peck. Using 'endowed props' in scenario-based design. In *Proceedings of the Nordic Conference on Human-computer Interaction*, pages 1–10, 2002.

[187] Andrew Hugill. *'Pataphysics: A Useless Guide*. The MIT Press, 2012.

[188] Johan Huizinga. Homo ludens: A study of the play-element in culture. *Routledge & Kegan Paul*, 1949.

[189] Andy Hunt and Marcelo M Wanderley. Mapping performer parameters to synthesis engines. *Organised Sound*, 7(2):97, 2002.

[190] Hilary Hutchinson, Wendy Mackay, Bo Westerlund, Benjamin B Bederson, Allison Druin, Catherine Plaisant, Michel Beaudouin-Lafon, Stéphane Conversy, Helen Evans, Heiko Hansen, et al. Technology probes: inspiring design for and with families. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 17–24, 2003.

[191] Tom Igoe. Physical computing's greatest hits (and misses). Online: https://www.tigoe.com/blog/category/physicalcomputing/176/ - last access April 14, 2023, 2008.

[192] Don Ihde. *Technology and the Lifeworld: From Garden to Earth*. Indiana University Press, 1990.

[193] Jonathan Impett. The contemporary musician and the production of knowledge. *Artistic Research in Music: Discipline and Resistance: Artists and Researchers at the Orpheus Institute*, pages 221–238, 2017.

[194] Jonathan Impett. Music, discourse and intuitive technology. *AI & SOCIETY*, pages 1–12, 2021.

[195] Tim Ingold. The textility of making. *Cambridge Journal of Economics*, 34(1): 91–102, 2010.

[196] Tim Ingold. *Making: Anthropology, archaeology, art and architecture*. Routledge, 2013.

[197] Sheheera Ismail, Patrick Gaydecki, Thomas Lloyd, and Hans Johannsson. Real-time emulation of the acoustic violin using convolution and arbitrary eßqualization. *Journal of the Audio Engineering Society*, 65(5):367–376, 2017. doi: https://doi.org/10.17743/jaes.2016.0073.

[198] Ole Sejer Iversen and Tuck W Leong. Values-led participatory design - mediating the emergence of values. In *Proceedings of the Nordic Conference on Human-Computer Interaction*, 2012.

[199] Ole Sejer Iversen, Kim Halskov, and Tuck W Leong. Values-led participatory design. *CoDesign*, 8(2-3):87–103, 2012.

[200] Alfred Jarry. *Selected Works of Alfred Jarry*. London - Methuen, 1965 (1911). Trans. Roger Shattuck and Simon Watson Taylor.

[201] Alfred Jarry. *Exploits & Opinions of Doctor Faustroll, pataphysician: a neo-scientific novel*. Exact Change, 1996. Originally published in 1911 – available online.

[202] Alexander Refsum Jensenius and Michael J Lyons. *A nime reader: Fifteen years of new interfaces for musical expression*, volume 3. Springer, 2017.

[203] Andrew Johnston. Some opportunities for practice-based research for NIME. In *Proceedings of the Practice-Based Research Workshop at the International Conference on New Interfaces for Musical Expression*, 2014.

[204] Sergi Jordà and Sebastian Mealla. A methodological framework for teaching, evaluating and informing NIME design with a focus on mapping and expressiveness. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 233–238, 2014. URL http://www.nime.org/proceedings/2014/nime2014_472.pdf.

[205] Sergi Jordà and Sebastián Mealla. A methodological framework for teaching, evaluating and informing NIME design with a focus on expressiveness and mapping. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, volume 30, pages 233–238, 2014. URL http://www.nime.org/proceedings/2014/nime2014_472.pdf.

[206] Sergi Jordà, Daniel Gómez-Marín, Ángel Faraldo, and Perfecto Herrera. Drumming with style: From user needs to a working prototype. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, volume 16, pages 365–370, 2016. URL http://www.nime.org/proceedings/2016/nime2016_paper0071.pdf.

[207] Ajay Kapur, Eric Singer, Manjinder S. Benning, George Tzanetakis, and Trimpin Trimpin. Integrating hyperinstruments , musical robots & machine

musicianship for north Indian classical music. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 238–241, 2007. URL http://www.nime.org/proceedings/2007/nime2007_238.pdf.

[208] Kenji Kawakami. *99 More Unuseless Japanese Inventions: the Japanese Art of Chindogu*. Harper Collins, London, 1997.

[209] Os Keyes, Josephine Hoy, and Margaret Drouhard. Human-computer insurrection: Notes on an anarchist HCI. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 1–13, 2019.

[210] David Kirby. The future is now: Diegetic prototypes and the role of popular films in generating real-world technological development. *Social Studies of Science*, 40(1):41–70, 2010.

[211] David Kirsh. How marking in dance constitutes thinking with the body. *Versus, Quaderni di Studi Semiotici*, 113(15), 2011.

[212] David Kirsh. Embodied cognition and the magical future of interaction design. *ACM Transactions on Computer-Human Interaction*, 20(1):1–30, 2013.

[213] Friedrich A Kittler. *Gramophone, film, typewriter*. Stanford University Press, 1999.

[214] Reinhart Koselleck. *Futures Past: on the Semantics of Historical Time*. Columbia University Press, 2004.

[215] Melvin Kranzberg. Technology and history: "kranzberg's laws". *Technology and culture*, 27(3):544–560, 1986.

[216] Richard A Lanham. *A Handlist of Rhetorical Terms*. University of California Press, 1991.

[217] Bruno Latour et al. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford University Press, 2005.

[218] Jean Lave and Etienne Wenger. *Situated Learning: Legitimate Peripheral Participation*. Cambridge University Press, 1991.

[219] Christopher A Le Dantec, Erika Shehan Poole, and Susan P Wyche. Values as lived experience: evolving value sensitive design in support of value discovery. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 1141–1150, 2009.

[220] Christopher A Le Dantec, Erika Shehan Poole, and Susan P Wyche. Values as lived experience: Evolving value sensitive design in support of value discovery. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 1141–1150, 2009.

[221] Henri Lefebvre. Towards a leftist cultural politics: Remarks occasioned by the centenary of marx's death, 1988. *Marxism and the Interpretation of Culture*, 75:88, 1991.

[222] Thomas Leitch. *The Oxford Handbook of Adaptation Studies*. Oxford University Press, 2017.

[223] Marc Leman. *Embodied Music Cognition and Mediation Technology*. MIT press, 2008.

[224] Giacomo Lepri. Sonification as negotiation - learning from translation studies. In *Proceedings of the Sound and Music Computing Conference*, pages 212–219, 2020. URL https://zenodo.org/record/3898761.

[225] Giacomo Lepri and Andrew McPherson. Making up instruments: Design fiction for value discovery in communities of musical practice. In *Proceedings of the Designing Interactive System Conference*, page 113–126, 2019.

[226] Giacomo Lepri and Andrew McPherson. Embrace the weirdness: Negotiating values inscribed into music technology. *Computer Music Journal*, forthcoming.

[227] Giacomo Lepri and Andrew P. McPherson. Mirroring the past, from typewriting to interactive art: an approach to the re-design of a vintage technology. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 328–333, 2018. URL http://www.nime.org/proceedings/2018/nime2018_paper0069.pdf.

[228] Giacomo Lepri and Andrew P. McPherson. Fictional instruments, real values: Discovering musical backgrounds with non-functional prototypes. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 122–127, 2019. URL http://www.nime.org/proceedings/2019/nime2019_paper024.pdf.

[229] Giacomo Lepri, Andrew McPherson, and John Bowers. Useless, not worthless: Absurd making as critical practice. In *Proceedings of the Designing Interactive Systems Conference*, 2020.

[230] Giacomo Lepri, Andrew McPherson, Antonella Nonnis, Pete Bennett, Kristina Andersen, Paul Stapleton, Tom Mudd, Sam Topley, and John Bowers. Play make believe: Exploring design fiction and absurd making for critical NIME design. 10.000 Musical Instruments for a Semi-connected World - *Accepted Workshop at the International Conference on New Interfaces for Musical Expression*, 2020. URL http://instrumentslab.org/research/10000-instruments.html.

[231] Martin Matus Lerner. Latin american NIMEs: Electronic musical instruments and experimental sound devices in the twentieth century. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 228–233, 2019. URL http://www.nime.org/proceedings/2019/nime2019_paper044.pdf.

[232] George E Lewis. Too many notes: Computers, complexity and culture in voyager. *Leonardo Music Journal*, pages 33–39, 2000.

[233] Linda C Li, Jeremy M Grimshaw, Camilla Nielsen, Maria Judd, Peter C Coyte, and Ian D Graham. Evolution of wenger's concept of community of practice. *Implementation Science*, 4(1):1–8, 2009.

[234] Joseph Lindley and Paul Coulton. Back to the future: 10 years of design fiction. In *Proceedings of the 2015 British HCI Conference*, pages 210–211, 2015.

[235] Szu-Yu Liu, Jen Liu, Kristin Dew, Patrycja Zdziarska, Maya Livio, and Shaowen Bardzell. Exploring noticing as method in design research. In *Companion Publication of the Designing Interactive Systems Conference*, pages 377–380, 2019.

[236] Deirdre Loughridge and Thomas Patteson. The museum of immaginary instruments, 2013 - present. http://imaginaryinstruments.org/about/ - last access April 14, 2023.

[237] Andrés Lucero, Audrey Desjardins, Carman Neustaedter, Kristina Höök, Marc Hassenzahl, and Marta E Cecchinato. A sample of one: First-person research methods in HCI. In *Companion Publication of the Designing Interactive Systems Conference*, 2019.

[238] Alvin Lucier. Careful listening is more important then making sounds happen (1975). In *Reflections: Interviews, Scores, Writings*, pages 430–438. Musik-Texte, 1995.

[239] Thor Magnusson. Of epistemic tools: Musical instruments as cognitive extensions. *Organised Sound*, 14(2):168–176, 2009.

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

[241] Thor Magnusson. Algorithms as scores: Coding live music. *Leonardo Music Journal*, pages 19–23, 2011.

[242] Thor Magnusson. Confessions of a live coder. In *Proceedings of the International Computer Music Conference*, 2011.

[243] Thor Magnusson. Ergomimesis: Towards a language describing instrumental transductions. In *Proceedings of the International Conference on Live Interfaces*, 2018.

[244] Thor Magnusson. *Sonic Writing: Technologies of Material, Symbolic, and Signal Inscriptions*. Bloomsbury Academic, 2019.

[245] Joseph Malloch, Stephen Sinclair, and Marcelo M Wanderley. A network-based framework for collaborative development and performance of digital musical instruments. In *International Symposium on Computer Music Modeling and Retrieval*, pages 401–425. Springer, 2007.

[246] Clara Mancini. Animal-computer interaction: a manifesto. *interactions*, 18(4): 69–73, 2011.

[247] Adnan Marquez-Borbon. Perceptual learning and the emergence of performer-instrument interactions with digital music systems. In *Proceedings of A Body of Knowledge - Embodied Cognition and the Arts Conference*, pages 1–23, 2016.

[248] Adnan Marquez-Borbon. Collaborative learning with interactive music systems. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 581–586, 2020. URL https://www.nime.org/proceedings/2020/nime2020_paper113.pdf.

[249] Adnan Marquez-Borbon and Juan Pablo Martinez-Avila. The problem of DMI adoption and longevity: Envisioning a NIME performance pedagogy. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 190–195, 2018. URL http://www.nime.org/proceedings/2018/nime2018_paper0040.pdf.

[250] Adnan Marquez-Borbon and Paul Stapleton. Fourteen years of NIME: The value and meaning of 'community' in interactive music research. In Edgar Berdahl and Jesse Allison, editors, *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 307–312, 2015. URL http://www.nime.org/proceedings/2015/nime2015_308.pdf.

[251] Andrea Martelloni, Andrew McPherson, and Mathieu Barthet. Percussive fingerstyle guitar through the lens of NIME: an interview study. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 440–445, 2020. URL https://www.nime.org/proceedings/2020/nime2020_paper85.pdf.

[252] Karl Marx. *The Capital - Volume I*. Penguin UK, 2004.

[253] Karl Marx. Speech at anniversary of the people's paper. In *Marx and Engels: Collected Works*, volume 14, pages 655–657. Lawrence & Wishart, 2010.

[254] John McCarthy and Peter Wright. Putting 'felt-life'at the centre of human–computer interaction (HCI). *Cognition, technology & work*, 7(4):262–271, 2005.

[255] James McCartney. Rethinking the computer music language: Supercollider. *Computer Music Journal*, 26(4):61–68, 2002.

[256] Marshall McLuhan. *Understanding Media: the Extensions of Man*. McGraw-Hill, 1964.

[257] Andrew McPherson. Touchkeys: Capacitive multi-touch sensing on a physical keyboard. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, 2012. URL http://www.nime.org/proceedings/2012/nime2012_195.pdf.

[258] Andrew McPherson and Giacomo Lepri. Beholden to our tools: Negotiating with technology while sketching digital instruments. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 434–439, 2020. URL https://www.nime.org/proceedings/2020/nime2020_paper84.pdf.

[259] Andrew McPherson and Koray Tahıroğlu. Idiomatic patterns and aesthetic influence in computer music languages. *Organised Sound*, 25(1):53–63, 2020.

[260] Andrew McPherson and Victor Zappi. An environment for submillisecond-latency audio and sensor processing on beaglebone black. In *Audio Engineering Society Convention*. Audio Engineering Society, 2015.

[261] Andrew McPherson, Robert Jack, and Giulio Moro. Action-sound latency: Are our tools fast enough? In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 20–25, 2016. URL http://www.nime.org/proceedings/2016/nime2016_paper0005.pdf.

[262] Andrew McPherson, Fabio Morreale, and Jacob Harrison. Musical instruments for novices: Comparing NIME, HCI and crowdfunding approaches. In *New Directions in Music and Human-Computer Interaction*, pages 179–212. Springer, 2019.

[263] George Herbert Mead. *Mind, Self and Society*, volume 111. Chicago University of Chicago Press., 1934.

[264] Carolina Brum Medeiros and Marcelo M Wanderley. A comprehensive review of sensors and instrumentation methods in devices for musical expression. *Sensors*, 14(8):13556–13591, 2014.

[265] Lia Mice and Andrew McPherson. From miming to nimeing: the development of idiomatic gestural language on large scale DMIs. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 570–575, 2020. URL https://www.nime.org/proceedings/2020/nime2020_paper111.pdf.

[266] Paul Milgram and Fumio Kishino. A taxonomy of mixed reality visual displays. *IEICE Transactions on Information and Systems*, 77(12):1321–1329, 1994.

[267] Evgeny Morozov. *To Save Everything, Click Here: The Folly of Technological Solutionism*. Public Affairs, 2013.

[268] Fabio Morreale and Andrew McPherson. Design for longevity: Ongoing use of instruments from NIME 2010-14. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 192–197, 2017. URL http://www.nime.org/proceedings/2017/nime2017_paper0036.pdf.

[269] Fabio Morreale, Antonella De Angeli, and Sile O'Modhrain. Musical interface design: An experience-oriented framework. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 467–472, 2014. URL http://www.nime.org/proceedings/2014/nime2014_437.pdf.

[270] Fabio Morreale, Andrew P. McPherson, and Marcelo Wanderley. NIME identity from the performer's perspective. In *Proceedings of the International Con-*

ference on New Interfaces for Musical Expression, pages 168–173, 2018. URL http://www.nime.org/proceedings/2018/nime2018_paper0036.pdf.

[271] Fabio Morreale, S. M. Astrid Bin, Andrew McPherson, Paul Stapleton, and Marcelo Wanderley. A NIME of the times: Developing an outward-looking political agenda for this community. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 160–165, 2020. URL https://www.nime.org/proceedings/2020/nime2020_paper31.pdf.

[272] Serge Moscovici. Foreword. In C. Herzlich, editor, *Health and Illness: A Social Psychological Analysis*. London/New York: Academic Press, 1973.

[273] Serge Moscovici. *Social Representations: Essays in Social Psychology*. NYU Press, 2001.

[274] Tom Mudd. Material-oriented musical interactions. In *New Directions in Music and Human-Computer Interaction*, pages 123–133. Springer, 2019.

[275] Tim Murray-Browne, Di Mainstone, Nick Bryan-Kinns, and Mark D. Plumbley. The medium is the message: Composing instruments and performing mappings. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 56–59, 2011. URL http://www.nime.org/proceedings/2011/nime2011_056.pdf.

[276] Tim Murray-Browne, Dom Aversano, Susanna Garcia, Wallace Hobbes, Daniel Lopez, Tadeo Sendon, Panagiotis Tigas, Kacper Ziemianin, and Duncan Chapman. The cave of sounds: An interactive installation exploring how we create music together. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 307–310, 2014. URL http://www.nime.org/proceedings/2014/nime2014_288.pdf.

[277] Chris Nash. The cognitive dimensions of music notations. In *Proceedings of the International Conference on Technologies for Music Notation and Representation*, pages 190–202, Paris, France, 2015.

[278] Chris Nash. The 'E' in QWERTY: Musical expression with old computer interfaces. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 224–229, 2016. URL http://www.nime.org/proceedings/2016/nime2016_paper0045.pdf.

[279] Carman Neustaedter and Phoebe Sengers. Autobiographical design in HCI research: designing and learning through use-it-yourself. In *Proceedings of the Designing Interactive Systems Conference*, pages 514–523, 2012.

[280] Dan Newton and Mark T. Marshall. The augmentalist: Enabling musicians to develop augmented musical instruments. In *Proceedings of the International Conference on Tangible, Embedded, and Embodied Interaction*, page 249–252, 2010.

[281] Luc Nijs. The merging of musician and musical instrument: Incorporation, presence, and levels of embodiment. In *The Routledge Companion to Embodied Music Interaction*, pages 49–57. Routledge, 2017.

[282] Luc Nijs, Micheline Lesaffre, and Marc Leman. The musical instrument as a natural extension of the musician. In *Proceedings of the 5th Conference of Interdisciplinary Musicology*, pages 132–144. LAM-Institut jean Le Rond d'Alembert, 2009.

[283] Donald A Norman. *The Psychology of Everyday Things*. Basic Books, 1988.

[284] Donald A Norman. Affordance, conventions, and design. *interactions*, 6(3): 38–43, 1999.

[285] Donald A Norman. The way I see it - Signifiers, not affordances. *interactions*, pages 18–19, 2008.

[286] Željko Obrenović. Design-based research: what we learn when we engage in design of interactive systems. *interactions*, 18(5):56–59, 2011.

[287] Judith S Olson and Wendy A Kellogg. *Ways of Knowing in HCI*, volume 2. Springer, 2014.

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

[289] Antti Oulasvirta, Esko Kurvinen, and Tomi Kankainen. Understanding contexts by being there: case studies in bodystorming. *Personal and Ubiquitous Computing*, 7(2):125–134, 2003.

[290] Jussi Parikka. *What Is Media Archaeology?* John Wiley & Sons, 2013.

[291] Blaise Pascal. *The Thoughts of Blaise Pascal*. Liberty Fund, 1669.

[292] Marcus Pearce and Geraint A Wiggins. Aspects of a cognitive theory of creativity in musical composition. In *Proceedings of the ECAI02 Workshop on Creative Systems*. Citeseer, 2002.

[293] Hannah Perner-Wilson, Leah Buechley, and Mika Satomi. Handcrafting textile interfaces from a kit-of-no-parts. In *Proceedings of the International Conference on Tangible, Embedded, and Embodied Interaction*, pages 61–68, 2010.

[294] Jean Piaget and Bärbel Inhelder. *The Psychology of the Child*. Basic books, 1969.

[295] James Pierce and Eric Paulos. Some variations on a counterfunctional digital camera. In *Proceedings of the Designing Interactive Systems Conference*, pages 131–140. ACM, 2014.

[296] Jon Pigrem and Andrew P. McPherson. Do we speak sensor? cultural constraints of embodied interaction. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 382–385, 2018.

[297] Trevor Pinch and Frank Trocco. The social construction of the early electronic music synthesizer. *Icon*, pages 9–31, 1998.

[298] Kamila Pope. *Understanding Planned Obsolescence: Unsustainability through Production, Consumption and Waste Generation*. Kogan Page Publishers, 2017.

[299] Irene Posch and Geraldine Fitzpatrick. The matter of tools: Designing, using and reflecting on new tools for emerging etextile craft practices. *ACM Transactions on Computer-Human Interaction*, 28(1):1–38, 2021.

[300] Miller Puckette. Max at seventeen. *Computer Music Journal*, 26(4):31–43, 2002.

[301] Miller Puckette. The deadly embrace between music software and its users. In *Proceedings of the Electroacoustic Music Studies Network Conference*, pages 1–8. http://www.ems-network.org/, 2014.

[302] Miller S Puckette. Pure data. In *Proceedings of the International Computer Music Conference*, 1997.

[303] Courtney N. Reed and Andrew P. McPherson. Surface electromyography for sensing performance intention and musical imagery in vocalists. In *Proceedings of the International Conference on Tangible, Embedded, and Embodied Interaction*, 2021.

[304] Erica Robles and Mikael Wiberg. Texturing the material turn in interaction design. In *Proceedings of the International Conference on Tangible, Embedded, and Embodied Interaction*, pages 137–144, 2010.

[305] Davide Rocchesso, Stefano Delle Monache, and Stephen Barrass. Interaction by ear. *International Journal of Human-Computer Studies*, pages 152–159, 2019.

[306] Jennifer A. Rode. Reflexivity in digital anthropology. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, page 123–132, 2011.

[307] Matthew Rodger, Paul Stapleton, Maarten van Walstijn, Miguel Ortiz, and Laurel S Pardue. What makes a good musical instrument? a matter of processes, ecologies and specificities. In Romain Michon and Franziska Schroeder, editors, *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 405–410, 2020. URL https://www.nime.org/proceedings/2020/nime2020_paper79.pdf.

[308] Robert Rosenberger and Peter-Paul Verbeek. *Postphenomenological Investigations: Essays on Human-technology Relations*. Lexington Books, 2015.

[309] Daniela K. Rosner. The material practices of collaboration. In *Proceedings of the Conference on Computer Supported Cooperative Work*, page 1155–1164, 2012.

[310] Daniela K Rosner. *Critical Fabulations: Reworking the Methods and Margins of Design*. MIT Press, 2018.

[311] Gery W Ryan and H Russell Bernard. Techniques to identify themes. *Field methods*, 15(1):85–109, 2003.

[312] Joel Ryan. Some remarks on musical instrument design at steim. *Contemporary music review*, 6(1):3–17, 1991.

[313] Erik Sandelin and Sarah Homewood. Design (in) actions. In *Proceedings of the Nordic Conference on Human-Computer Interaction*, pages 1–9, 2020.

[314] Sylviane Sapir. Personal communication.

[315] Jean-Paul Sartre. Existentialism is a humanism. Lecture given in 1946 – First Published: World Publishing Company in 1956, 1946.

[316] John W Satzinger and Lorne Olfman. User interface consistency across end-user applications: the effects on mental models. *Journal of Management Information Systems*, 14(4):167–193, 1998.

[317] Geoffrey B Saxe. Cognition, development, and cultural practices. *New Directions for Child and Adolescent Development*, 1999(83):19–35, 1999.

[318] Norbert Schnell and Marc Battier. Introducing composed instruments, technical and musicological implications. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 156–160, 2002. URL http://www.nime.org/proceedings/2002/nime2002_156.pdf.

[319] Donald A Schön. *The Reflective Practitioner: How Professionals Think in Action*. Basic books, 1983.

[320] Alfred Schutz. *The Phenomenology of the Social World*. Northwestern University Press, 1972.

[321] Phoebe Sengers and Bill Gaver. Staying open to interpretation: Engaging multiple meanings in design and evaluation. In *Proceedings of the Designing Interactive Systems Conference*, pages 99–108, 2006.

[322] Phoebe Sengers, Kirsten Boehner, Shay David, and Joseph'Jofish' Kaye. Reflective design. In *Proceedings of the 4th Decennial Conference on Critical Computing: Between Sense and Sensibility*, pages 49–58, 2005.

[323] Emanuele Severino. *La Filosofia Futura*. Rizzoli, Milano, 1989.

[324] Emanuele Severino. *The Essence of Nihilism*. Verso Books, 2016.

[325] Jonathan Shear and Francisco J. Varela. *The View from Within: First-person Approaches to the Study of Consciousness*. Consciousness Studies. Imprint Academic, 1999.

[326] Jennifer G Sheridan. Digital arts entrepreneurship: Evaluating performative interaction. In *Interactive Experience in the Digital Age*, pages 243–259. Springer, 2014.

[327] Katie Shilton. Values and ethics in human-computer interaction. *Foundations and Trends in Human–Computer Interaction*, 12(2), 2018.

[328] Viktor Shklovsky. Art as technique. *Contemporary Literary Criticism. Modernism Through Poststructuralism*, 1917.

[329] Jesper Simonsen and Toni Robertson. *Routledge International Handbook of Participatory Design*. Routledge, 2012.

[330] Jesper Simonsen, Connie Svabo, Sara Malou Strandvad, Kristine Samson, and Morten Hertzum. *Situated Design Methods*. Mit Press, 2014.

[331] Paul Stapleton, Simon Waters, Nick Ward, and Owen Green. Distributed agency in performance, 2016. Workshop at the International Conference on Live Interfaces.

[332] George Steiner. *After Babel: Aspects of Language and Translation*. Oxford University Press, 1998.

[333] B Sterling. Fantasy prototypes and real disruption – keynote next berlin 2013, 2013. URL https://www.youtube.com/watch?v=M7KErICTSHU. last access April 14, 2023.

[334] Dan Stowell, Mark D. Plumbley, and Nick Bryan-Kinns. Discourse analysis evaluation method for expressive musical interfaces. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 81–86, 2008. URL http://www.nime.org/proceedings/2008/nime2008_081.pdf.

[335] Detmar Straub, Karen Loch, Roberto Evaristo, Elena Karahanna, and Mark Srite. Toward a theory-based measurement of culture. *Human Factors in Information Systems*, 10(1):61–65, 2002.

[336] Lucy A Suchman. *Plans and Situated Cctions: The Problem of Human-Machine Communication*. Cambridge university press, 1987.

[337] Lucy A Suchman. Practice-based design of information systems: Notes from the hyperdeveloped world. *The information society*, 18(2):139–144, 2002.

[338] David Sudnow. *Ways of the hand: The organization of improvised conduct*. MIT Press, 1993.

[339] Superflux. Drone aviary. video, 2015. URL https://vimeo.com/124292043. last access April 14, 2023.

[340] Alexandra Supper. Trained ears and correlation coefficients: a social science perspective on sonification. In *Proceedings of the International Conference on Auditory Display*, 2012.

[341] Koray Tahiroglu, Michael Gurevich, and R. Benjamin Knapp. Contextualising idiomatic gestures in musical interactions with NIMEs. In Thomas Martin Luke Dahl, Douglas Bowman, editor, *Proceedings of the International Con-*

ference on New Interfaces for Musical Expression, pages 126–131, 2018. URL http://www.nime.org/proceedings/2018/nime2018_paper0028.pdf.

[342] Koray Tahıroğlu, Thor Magnusson, Adam Parkinson, Iris Garrelfs, and Atau Tanaka. Digital musical instruments as probes: How computation changes the mode-of-being of musical instruments. *Organised Sound*, 25(1):64–74, 2020.

[343] Ezra Teboul. The transgressive practices of silicon luthiers. In *Guide to Unconventional Computing for Music*, pages 85–120. Springer, 2017.

[344] Paul Théberge. *Any Sound you Can Imagine: Making Music/Consuming technology*. Wesleyan University Press, 1997.

[345] Paul Théberge. Musical instruments as assemblage. In *Musical Instruments in the 21st Century*, pages 59–66. Springer, 2017.

[346] Enrique Tomás. Politics of musical interfaces: Ideologies and digital disenchantment. In *Proceedings of the First International Conference on Interface Politics*, 2016.

[347] Enrique Tomás. A playful approach to teaching nime: Pedagogical methods from a practice-based perspective. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 143–148, 2020. URL https://www.nime.org/proceedings/2020/nime2020_paper28.pdf.

[348] Giuseppe Torre and Kristina Andersen. Instrumentality, time and perseverance. In *Musical Instruments in the 21st Century*, pages 127–136. Springer, 2017.

[349] Giuseppe Torre, Kristina Andersen, and Frank Baldé. The hands: The making of a digital musical instrument. *Computer Music Journal*, 40(2):22–34, 2016.

[350] João Tragtenberg, GG Albuquerque, and Filipe Calegario. Gambiarra and techno-vernacular creativity in NIME research. In *Proceedings of the Conference on New Interfaces for Musical Expression*, 2021 - forthcoming.

[351] Giovanni M Troiano, Alberto Boem, Giacomo Lepri, and Victor Zappi. Non-rigid musical interfaces: Exploring practices, takes, and future perspective. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 17–22, 2020. URL https://www.nime.org/proceedings/2020/nime2020_paper3.pdf.

[352] Luca Turchet. Smart mandolin: autobiographical design, implementation, use cases, and lessons learned. In *Proceedings of the Audio Mostly Conference*, pages 1–7. 2018.

[353] Anna Vallgårda and Johan Redström. Computational composites. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 513–522, 2007.

[354] Jeroen Van den Hoven, P Vermaas, and Ibo Van de Poel. *Handbook of Ethics, Values and Technological Design*. Springer, 2015.

[355] Juan Vasquez, Koray Tahiroğlu, and Johan Kildal. Idiomatic composition practices for new musical instruments: Context, background and current applications. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 174–179, 2017. URL http://www.nime.org/proceedings/2017/nime2017_paper0033.pdf.

[356] Bill Verplank. Interaction design sketchbook. *Unpublished paper for CCRMA music course*, 2003.

[357] John Vines, Mark Blythe, Stephen Lindsay, Paul Dunphy, Andrew Monk, and Patrick Olivier. Questionable concepts: Critique as resource for designing with eighty somethings. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 1169–1178, 2012.

[358] Erich M Von Hornbostel and Curt Sachs. Classification of musical instruments. *The Galpin Society Journal*, pages 3–29, 1961.

[359] Lev Semenovich Vygotsky. *Mind in Society: The Development of Higher Psychological Processes*. Harvard university press, 1980.

[360] Michel Waisvisz. Riding the sphinx—lines about 'live'. *Contemporary Music Review*, 18(3):119–126, 1999.

[361] Ron Wakkary, William Odom, Sabrina Hauser, Garnet Hertz, and Henry Lin. Material speculation: Actual artifacts for critical inquiry. In *Proceedings of The Fifth Decennial Aarhus Conference on Critical Alternatives*, pages 97–108. Aarhus University Press, 2015.

[362] Ron Wakkary, Doenja Oogjes, Sabrina Hauser, Henry WJ Lin, Cheng Cao, Leo Ma, and Tijs Duel. Morse things: A design inquiry into the gap between

things and us. In *Proceedings of the Designing Interactive Systems Conference*, pages 503–514, 2017.

[363] Ron Wakkary, Doenja Oogjes, Henry WJ Lin, and Sabrina Hauser. Philosophers living with the tilting bowl. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 1–12, 2018.

[364] Diane Waldman and Henri Matisse. *Collage, Assemblage, and the Found Object*. Phaidon London, 1992.

[365] Marcelo M Wanderley, Philippe Depalle, and Olivier Warusfel. Improving instrumental sound synthesis by modeling the effects of performer gesture. In *Proceedings of the International Computer Music Conference*. MIT Press, 1999.

[366] Marcelo Mortensen Wanderley and Nicola Orio. Evaluation of input devices for musical expression: Borrowing tools from HCI. *Evaluation*, 26(3), 2006.

[367] Ge Wang, Perry R Cook, and Spencer Salazar. Chuck: A strongly timed computer music language. *Computer Music Journal*, 39(4):10–29, 2015.

[368] Simon Waters. The entanglements which make instruments musical: Rediscovering sociality. *Journal of New Music Research*, 50(2):133–146, 2021.

[369] Etienne Wenger. *Communities of Practice: Learning, Meaning and Identity*. Cambridge University Press, 1998.

[370] Etienne Wenger and Jean Lave. Legitimate peripheral participation in communities of practice. In *Supporting lifelong learning*, pages 121–136. Routledge, 2001.

[371] Etienne Wenger, Richard Arnold McDermott, and William Snyder. *Cultivating Communities of Practice: A Guide to Managing Knowledge*. Harvard business press, 2002.

[372] David Wessel and Matthew Wright. Problems and prospects for intimate musical control of computers. *Computer Music Journal*, 26(3):11–22, 2002.

[373] Geraint A Wiggins, Daniel Müllensiefen, and Marcus T Pearce. On the nonexistence of music: Why music theory is a figment of the imagination. *Musicae Scientiae*, 14(1_suppl):231–255, 2010.

[374] Danielle Wilde, Anna Vallgårda, and Oscar Tomico. Embodied design ideation methods: Analysing the power of estrangement. In *Proceedings of*

the CHI Conference on Human Factors in Computing Systems, page 5158–5170, 2017.

[375] Langdon Winner. Do artifacts have politics? *Daedalus*, pages 121–136, 1980.

[376] Jill Palzkill Woelfer, Amy Iverson, David G Hendry, Batya Friedman, and Brian T Gill. Improving the safety of homeless young people with mobile phones: values, form and function. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 1707–1716. ACM, 2011.

[377] Anna Xambó. Who are the women authors in NIME? - improving gender balance in NIME research. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 174–177, 2018. URL http://www.nime.org/proceedings/2018/nime2018_paper0037.pdf.

[378] Iannis Xenakis. *Formalized Music: Thought and Mathematics in Composition*. Indiana University Press, 1971.

[379] Daisy Yoo, Alina Huldtgren, Jill Palzkill Woelfer, David G Hendry, and Batya Friedman. A value sensitive action-reflection model: evolving a co-design space with stakeholder and designer prompts. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 419–428. ACM, 2013.

[380] Gareth W Young and Dave Murphy. HCI models for digital musical instruments: Methodologies for rigorous testing of digital musical instruments. In *International Symposium on Computer Music Multidisciplinary Research*, 2015.

[381] Pamela Z. A tool is a tool. *Women, Art, and Technology*, pages 348–361, 2003.

[382] Victor Zappi and Andrew McPherson. Hackable instruments: Supporting appropriation and modification in digital musical interaction. *Frontiers in ICT*, 5:26, 2018.

[383] Victor Zappi, Andrew McPherson, et al. Design and use of a hackable digital instrument. In *Proceedings of the International Conference on Live Interfaces*, 2014.

[384] Luis Zayas, Jacob Harrison, Robert Jack, and Andrew McPherson. DMI apprenticeship: Sharing and replicating musical artefacts. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, forthcoming.

[385] John Zimmerman, Jodi Forlizzi, and Shelley Evenson. Research through design as a method for interaction design research in HCI. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, pages 493–502, 2007.

A

APPENDIX

The complete collection of artefact descriptions and pictures provided to the participants of the on-line survey presented in Chapter 3.

SonicAlarm

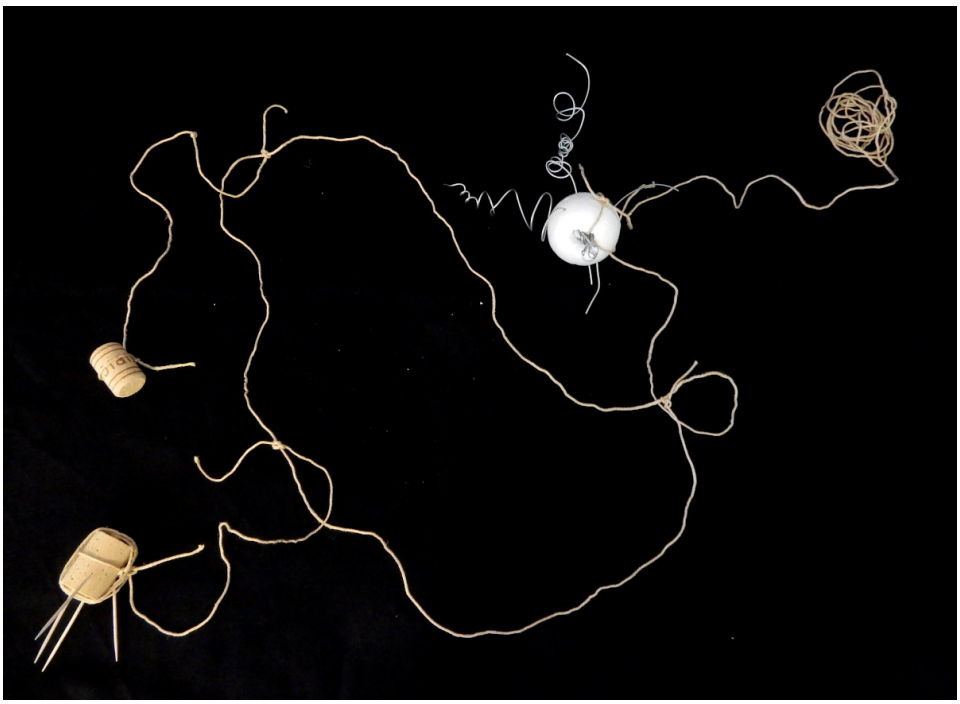


Figure A.1: *Sonic Alarms*

"The ball, stingers and corks with the toothpicks are the elements that produce sound [..] and the wires are like connectors between these elements. [..] This metal can interact in different ways with different materials and with the ball. I already got a considerable control [..] but then I thought, like this is just a controllable thing [..] let's add something that I can't control [..] So, I took two corks, and these being connected with the ball, they will move when the ball moves [..] The performeruses these wires as a sort of control interface [..] By moving these objects,

the objects also interact with each other and the sound is generated through this kind of interaction."

"At the beginning I thought about the clothespin, so that it could be thrown [..] I like the idea of throwing things [..] and maybe it would be nice to have an instrument in which you can throw things in the space [..] In reality the most interesting thing is that these ropes, they can be released or dragged [..] I also thought that I could connect it to a leg and move around."

"It should be something that I can control with one or two hands, so I did a hole in the ball I put the rope inside. Then I added various metal stingers with different dimensions and shapes [..] And I would have preferred to have them made of different materials [..] Like it would be nice if these could bounce."

CorpoSuono

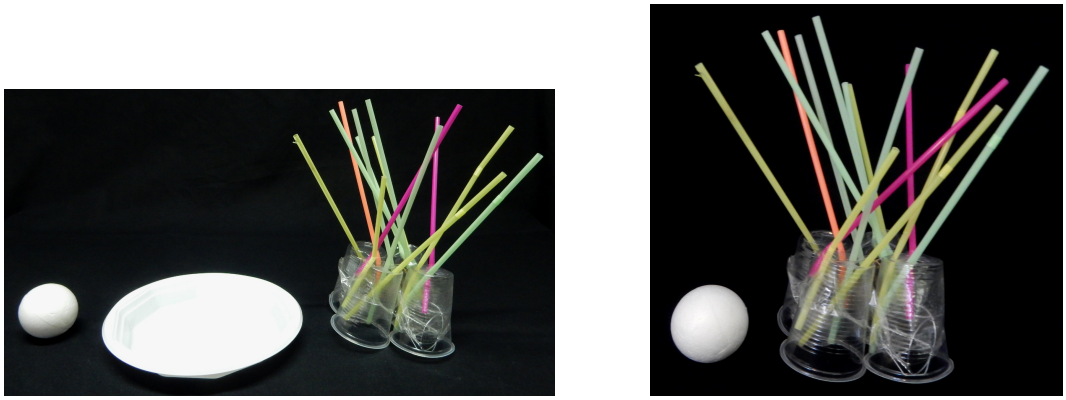


Figure A.2: *Corpo Souno*

"It is similar to the organ because it works thanks to the air that goes through the tubes [..] These tubes have different timbre and frequencies because there are made of different materials and different lengths [..] So each of them is conceived for a specific type of sound. Each 'room' filters the sound differently, sounds that go out from each room are different. I thought about a fan and with these balls you can block the sound and in relation to how much I let the air going in I can modify the intensity [..] Moreover, in relation to how much air I shoot from the

fan, let's say the power."

"It's for single musicians [..] But it could become for orchestra as well [..] this version is for children or soloist as well. It is very basic with limited sounds [..] But if we could use an entire wall, with different people [..] We could have a mezzanine and have different people that play upstairs and downstairs [..] Toproduce a well-balanced sound, the wider is the possibility, the more difficult it is to balance. Well not always, but there is always balance and density [..] Like a clarity of sounds but well-balanced. And this, in my view, could produce, even within a short scale, a variety of simple sounds but also much more complex and well-balanced sounds."

"Like an orchestral chord sound, full-bodied and well balanced [..] I thought about an entire wall with different people interacting on different levels."

Plucker

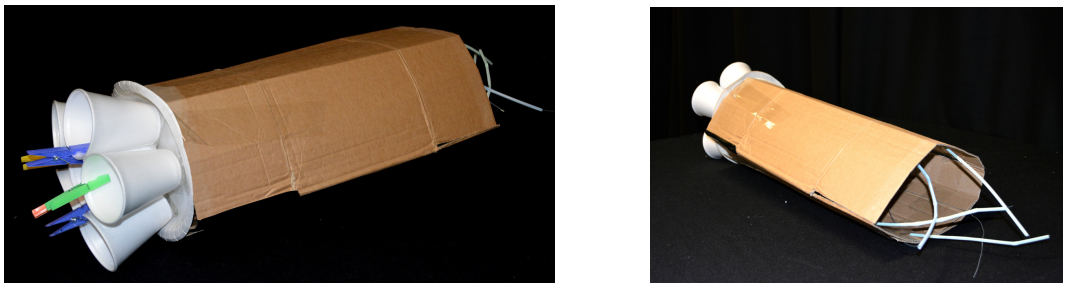


Figure A.3: *Plucker*

"I was thinking at the beginning like the way to alter the sound would be similarly to way the way that the French horn alters the pitch [..] I feel like if all of these kinds of speakers [cups], shall we say, are connected to like some kind of electrical current that will continue this noise [..] But at the same time, this electrical current, it's also able to be altered by your hand movements inside there to control [..] The volume perhaps, but definitely also the pitch [..] I was originally thinking of themlike the length or the thicknesses of wires or strings [..] Sometimes, you know, the way you stroke a certain string can alter the pitch depending on how much pressure you use on it [..] A similar kind of gesture was able to alter, you

know, the flow or the rate of flow of electricity [..] that's the volume or the pitch."

"I guess it's a sort of like organ sound that I have in mind [..] I want to sustain at a variable volume and I want to control [..] you have the five wires for each of the five points of the package [..] like each control by one finger [..] and then maybe if you didn't touch the strings at all electricity would stop! it relies on that kind of input."

"I was also thinking that each of these [wires] has like in some way a different pitch as well so there are a number of different strings inside of a different wire that you are able manipulating with the one hand [..] so that, yeah you could actually be operating something quite chordal altogether and moving quite polyphonically [..] I kind of imagined somethingquite drone like perhaps with a very consistent constant sound [..] to my ears like what I think of like a chorus of alphorns [..] it's sort of like that kind of consistency but also of that magnitude the sound is very enormous that too."

NonStopSound

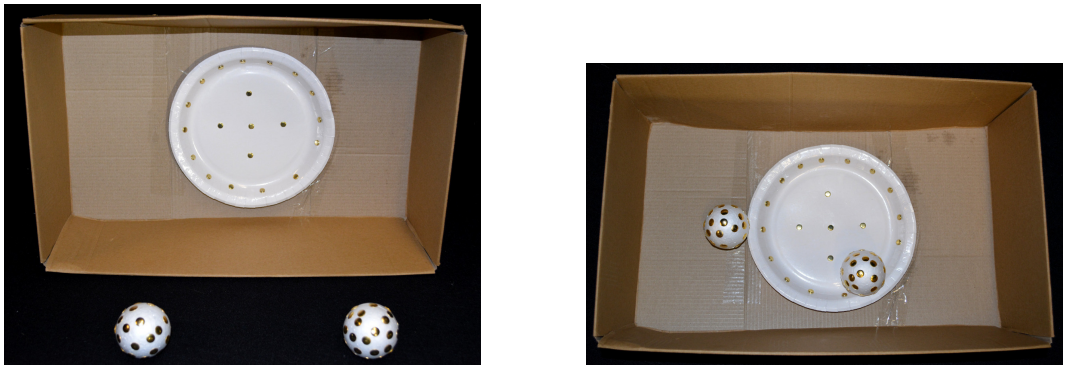


Figure A.4: *NonStopSound*

"I took the concept of non-stop sound and bubble [sound] and tried to make some kind of circular perpetual motion instrument that could roll in and create sounds [..] [The ball] is interacting with the different things like metals [..] But then they sometimes fall out and then it almost becomes like that game where you're trying to get the ball into [the hole]. And then I realised that it's really my style

[to] make a game of sound."

"The thing that I thought about working on was the sound that [..] just like in performance, no gaps between things [..] like there can still be a structure or many different pieces but blending everything together so that it never stops."

"It would create a rhythm of a sound, but it would always have slight differences because sometimes the metal is hitting each other and sometimes it's not. [..] I thought maybe it would be cool to put a different tone inside the box [..] like even if it was strings or something and then it rolls on different surfaces."

"Sometimes I like to makerandom things, but the randomness never ends up in the performance or in the songs or anything so [..] say if instead of pressing just a synth note this was generating a synth note but all the little tiny fragments were changing because of what it is interacting with [..] that's something I would definitely use in production."

AntennaLele

"I wanted an instrument that was able to play single notes, melodies and harmonies but with lots of flexibility [..] So, that's why it has a neck then you can fold in several parts to get different notes [..] That was the idea, to be able to get harmony and to shape that harmony along with it."

"And that's related to my image which is [a piece] I am listening to a lot lately that does not have drums, but it's like bass, piano and sax. I want to be able to play bass with my instrument, to play [..] slightly complex harmonies and melodies with lots of flexibility to shape with it."

"I guess if I would have managed to put this one [the neck] like with some tension it would have worked. And that's it. You can shape it to whatever you want."

Stochastico

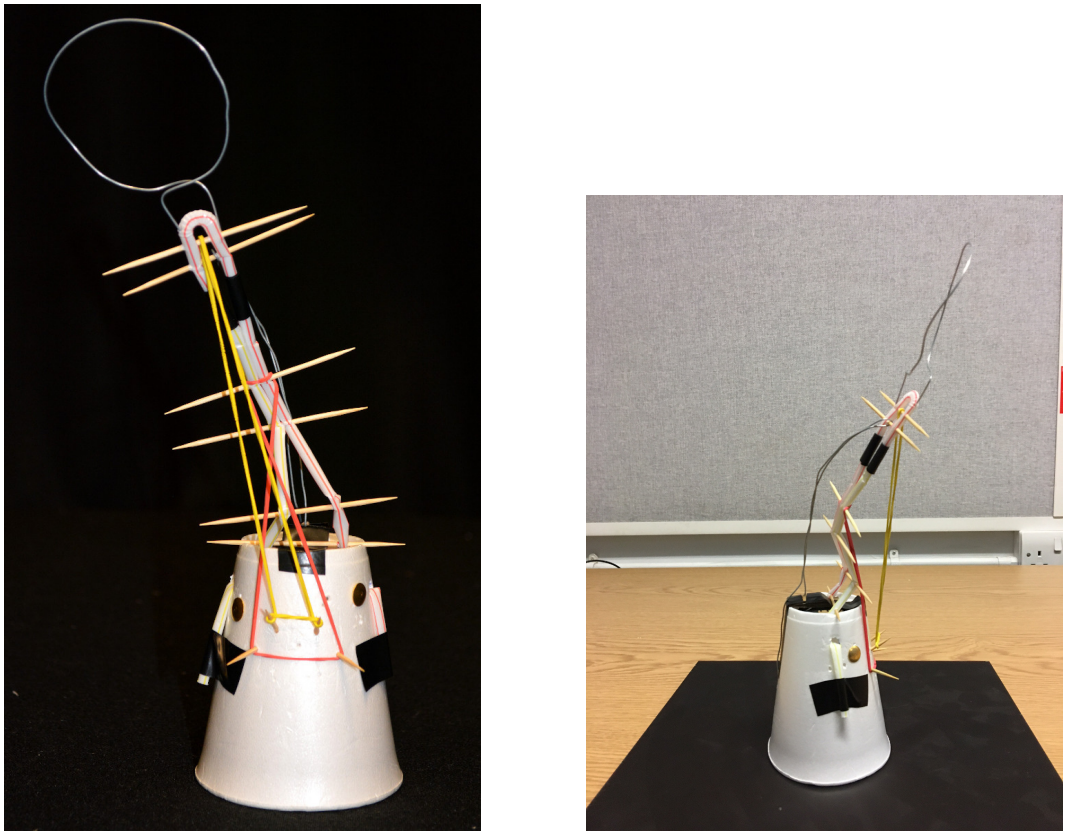


Figure A.5: *AntennaLele*

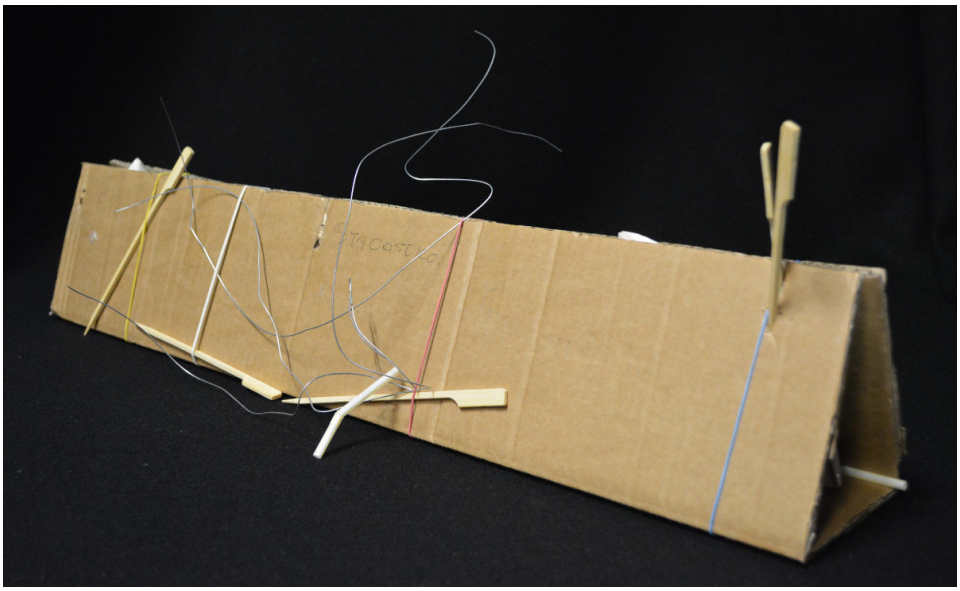


Figure A.6: *Stochastico*

"It's that's a sort of semi-percussion [..] sort of immediate thing. You see it doesn't look like anything, [..] I mean it doesn't look smart. So if you work on it,

you know you just have the reaction of the elastic bands [..] [I used] the wire, the elastic bands, the straws and the wooden sticks. [..] So, you could sort of move them around [..] these things act as a sort of moving threads [..] You move these [materials] around and it's just [to] provide some sort of background or kind of impetus."

"I'm afraid this is toostaccato and immediate [..] It's like when you're carving with the sound [..] That's what I'm doing [..] You could make, you know, start thinking of it and then making shapes with this."

"I usually do [..] shapes of sound [..] where I kind of conceive of a shape I'm going to make [..] you know, with my instrument, I sort of envisage the shape and then I play it sort of like carving in the air [..] you could start thinking of it and then making shapes with this [..] It just feels like when you know sometimes that the shape the sound makes a shape which is almost tangible [..] but [the sound of materials] is really staccato, sudden and momentary so it's not really what I want, but you know."