

# Instrumental Investigations at the Emute Lab

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## ABSTRACT

This lab report discusses recent projects and activities of the Experimental Music Technologies Lab at the University of Sussex. The lab was founded in 2014 and has contributed to the development of the field of new musical technologies. The report introduces the lab's agenda, gives examples of its activities through common themes and gives short description of lab members' work. The lab environment, funding income and future vision are also presented.

## Author Keywords

NIME, lab report, new technologies for musical expression.

## CCS Concepts

• Applied computing → Sound and music computing; • Applied computing → Arts and humanities → Performing arts; • CCS → Human Computer Interaction (HCI) → HCI design and evaluation methods → Laboratory experiments;

## 1. INTRODUCTION

The Experimental Music Technologies Lab was founded in early 2014 to create a sustainable platform for original research in music technologies at the University of Sussex. The aim was twofold: firstly, to maintain the existing research collaboration between the Music and Informatics departments at Sussex after some departmental restructuring, and, secondly, to create an outward-facing hub for collaborative activities and information source for researchers in other institutions and the general public. Sussex has a long tradition of research into computational creativity [4] and the development of new technologies for perception and expression, often related to the activities of the COGS centre (Centre of Cognitive Science) where perceptual prosthesis and artificial intelligence have been considered fruitful ways to study the human mind [10]. For us in the Emute Lab, musical instruments have been instruments for musical expression *as well as* instruments of science, following a millennia old tradition of scholarly enquiry [17]. Our artistic work is practice-based and in addition to interdisciplinary collaboration and lab-based research and development we see live musical performance as a laboratory setting.

The Emute Lab has organised concerts, exhibitions, workshops, symposia and conferences, on campus as well as in Brighton centre and in other cities. By joining forces we have been able to collaborate and share research with other scientists and people all over the world, following open science methods [18]. For lab members, the function of these activities goes beyond communication of research or "impact": they represent an essential activity to gather data from users and audience, feeding into the design of new systems or improvement of current work, as well as autoethnographic or ethnomethodological studies of our own experience as performers. This experience and

feedback of our research results in the next iteration of the work. We seek to do our research in the open, with people, encouraging people to use our technologies, as real users with specific defined artistic goals are the best commentators on artistic-research. A history of some organised lab events can be seen here: <http://www.emutelab.org/events>

## 2. RESEARCH THEMES AT EMUTE LAB

Members of the lab work equally independently and collaboratively on research projects. Our approach tends to be dynamic and quick groupings of people form around certain experiments or events. In the following sections we list our key activities under themes that have emerged as central nodes of focus in the lab's six years of operation.

### 2.1 Instrument Design

As musicians in the 21<sup>st</sup> century, instrument design has become a principal mode of composing [16]. The established notions of composer, performer and instrument designer have fused into more fluid terms like inventors, producers or simply musicians, where the musical piece is often an open system that is performed by the inventor. At the Emute lab we are all involved in instrument design ranging from musical pieces as instruments in the work of Ficarra or Magnusson to more substantial general instruments in the form of feedback instruments or modular audiovisual systems, such as the halldorophone (see below). Topics of expressivity, notation, sustainability and cultural adoption and adaptation of the instruments are all of interest. Based on interest in cognitive science accounts of embodiment and enactivism [20], the lab has focussed on building instruments that combine expressive gestural control of acoustic instruments with programmability of software instruments, and increasingly hybridised instruments which integrate these. We have a shared interest in extending human agency into material or computational processes, whether that is through acoustic or algorithmic properties. The methods are often a hybrid between music and engineering in terms of methodology, integrating intuition, technique, imagery as performer, with measurements and empirical analysis of engineering practice. Eldridge captures this well when she describes her approach to music research as "three-fold experimentation: experimenting as a musician (exploring musical paths of unknown outcomes a la Cage), as an engineer (tinkering, following hunches, testing things out in the real world), as a scientist (forming hypothesis and testing through empirical analyses)."

### 2.2 Live Coding

Live coding has been a prominent research trope at Sussex, long before the Emute Lab was established. The live coding pioneer Nick Collins (aka. Click Nilson) worked on live coding research at Sussex from 2005 and Thor Magnusson released his ixiQuarks system with live coding capability [14] around this time and ixi lang in 2008 [13]. Magnusson's latest live coding system is the Threnoscope [15]. In 2013, Magnusson and Alex McLean founded the Live Coding Research Network (LCRN), from an AHRC network grant, and organised various activities that promoted live coding research and development between 2014-16. The LCRN is still operating, and this year we saw the fifth instance of the International Live Coding



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Conference in Limerick, a conference emerged out of this network. Chris Kiefer is a long-term live coder and works on various systems for example the use of embedded mini-languages within other larger languages. Through the MIMIC research project (Musically Intelligent Machines Interacting Creatively), which is a collaboration with Goldsmiths College and Durham University, we gained a new member of the lab, Francisco Bernardo. Bernardo is currently working with Magnusson and Kiefer on developing the Sema live coding system [1] for live coding language design with machine learning [2].

### 2.3 Feedback Instruments

There is a pronounced research strand in the lab focusing on feedback instruments. A long-lasting interest by members of the lab, related to dynamical systems [7][11], the research of feedback as a design principle in instruments became grounded with the membership of Halldor Ulfarsson, whose research project is on the innovation of his electroacoustic, cello-like string instrument called halldorophone [19]. The halldorophone (**Figure 1**) has spawned further research projects, such as Eldridge and Kiefer's feedback cello project [9]; their current research investigates the application of language and mathematical tools of complexity and dynamical systems to understand and finesse the musical behaviour of feedback instruments. Eldridge and Kiefer are members of the *Brain Dead Ensemble* (**Figure 2**) together with Thanos Polymeneas Lontiris (feedback bass) and Thor Magnusson (Threnoscope). This is an acoustically network ensemble [18] that has performed widely and recently released an album, EFZ on Confront Recordings and featured on a Silent Records compilation (see [www.emutelab.org/label](http://www.emutelab.org/label)).



**Figure 1. The halldorophone**

### 2.4 Cybernetic and Dynamical Systems

Related to work in feedback instruments is a more general research focus on cybernetic and dynamical systems. Joe Watson has recently completed his doctoral research on the tape recording studio as a cybernetic system drawing inspiration from the ideas of artist-cybernetician Gordon Pask. Likewise, during his PhD at Sussex, Thanos Polymeneas-Lontiris created cybernetic immersive music theatre pieces where the audience would influence the inner workings of the piece and its realtime composition and progression. These works are often long-duration, generative and self-evolving performances, that incorporate human-computer or interpersonal interaction. Kiefer's conceptual synthesis [11] is another project that appears on intersections between machine learning and dynamical systems - training sound generators that are complex dynamical systems which can be manipulated further to change sound qualities. Much of the work exploring agency of musical instruments when system is literally self-determined is inspired by artificial life, cognitive science and cybernetics: topics at the heart of internationally renowned COGS centre for cognitive science (<http://www.sussex.ac.uk/cogs/>), with which many Emute Lab members are affiliated. Kiefer and Eldridge have also collaborated on evolutionary agent-based models of acoustic niche formation [9], exploring territory at the interstices of

experimental music, Alife and ecoacoustics, an area in which Eldridge has carried out pioneering research (see below).



**Figure 2. The Brain Dead Ensemble in action**

### 2.5 Musical Materialities

Various members of the lab study the material aspects of music and musical media. This ranges from the materialities of instruments to recording technologies to listening contexts. As an example, Dylan Beattie uses disc inscription technologies in an attempt to reframe 'record cutting' as a creative, performative and public-facing act through composition, performance and sound installation practices. Here the inscription and production technology is used as a creative driver for an archaeological approach into our historical technologies. Following a Musical Materialities conference in 2014, the Musical Materialities symposium was hosted in the Sussex Humanities Lab (2019) with associated live performances from guest speakers taking place at an arts venue in Brighton. Another lab member, Alex Peverett, investigates historical methods for the creation of electronic art and integrating them with contemporary practice to create hybrid procedural systems for the generation of synthetic audio-visual works. Interrogating and experimenting with ideas around analogue and the digital as signal at the material level.

Magnusson's work has engaged with the materiality of music from a theoretical perspective, whether as physical instruments and systems or algorithmic virtual musical software. In his recent book on *Sonic Writing*, he explores how musical practice is conditioned by technology and its evolution in human culture [16] but also on the phenomenological qualities of the instrument itself and its design, developed through the ideas of *ergodynamics* and *ergomimesis* [12].

### 2.6 Sound Installations

Lab members also work with sound installations as a mode of sonic expression. These include installations that become live instruments, for example with Chevalier and Kiefer's Listening Mirrors [5] that warps and blurs the boundaries between real and imagined realities, opening up a new space for participants to explore these two worlds as one through augmented reality hearing devices that interact with the perception of physical objects (see Figure 3). Other examples are Chevalier & Duff's *200.104.200.2* copper sound art installation, exhibited at NIME 2017, or Evelyn Ficarra's audiovisual installation that explores encounters between recorded digital artefacts and the physical world, searching for the 'voice of the object', and ways in which to engage musically with both the sonic and metaphoric resonance of objects. Another of Evelyn's interest is the 'death' of the object, often expressed through deconstructed pianos and smashed teacups. At the core of this is an investigation into agency for the composer, the listener and the object itself.

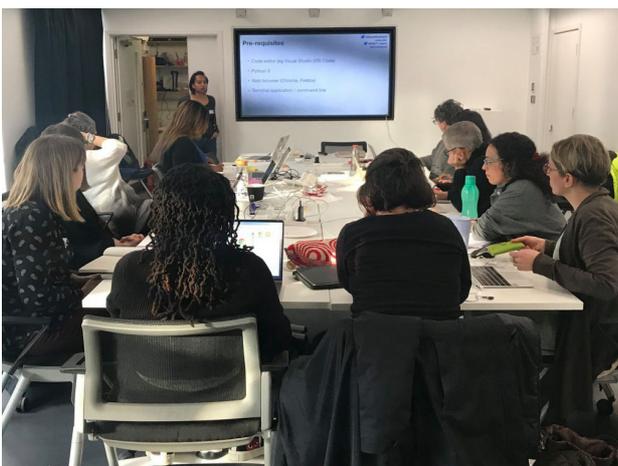


**Figure 3. Chevalier and Kiefer's Listening Mirrors installation**

Dylan Beattie is another member who works on installations, for example the Brecord sound art installation which focused on the language of Brexit presented in mainstream news media and particularly concerned with the notion of the performative portmanteau. The work comprises three 7-inch records reflecting repetition within tautological language, generative disc inscription cutting processes and composition responding to intensity of language. These were performed together and cut live to a fourth record. Danny Bright has created various installation works, such as the Chalk Pit (2014) which explores post-industrial sites in Sussex through multimodal sonic fracture. Bright is interested in the hauntology of landscapes, and his Ghosting the Periphery (2016) is a sonic ghosting work reflecting on the histories and spaces of the Hatton Gallery in Newcastle-upon-Tyne looking at how technology transforms our embodied relation in the world and how imagined instruments made real can form new expressions.

## 2.7 Feminist Approaches to Computational Technology

The FACT///.network (2018) was born from a desire to form and support a community around issues of representation, diversity and inclusion within the broad area of computational practices (e.g. coders, DIY coders, programmers) and thinking. It has created an active network and community within and beyond the Emute Lab that supports thinking of gender and representation in computing and encourages alternative demographics in current digital spaces, environments and practices from which computational thinking is made possible (Figure 4).



**Figure 4. From a FACT///.network workshop**

Throughout 2019-20 a programme called 'Feminist Approaches to Computational Technology: Read, Write, Code' was run by Cécile Chevalier and Sharon Webb, that includes coding space, materialising feminist voices and growing support community through a series of events (e.g. workshop, symposium, reading group and writing space).

## 2.8 Machine Listening

A former Sussex person, Nick Collins is an honorary member of our lab and he has conducted research into machine listening for over two decades and has released SuperCollider library for machine listening and as part of the MIMIC project he has developed a machine listening library for JavaScript (<https://github.com/sicklincoln>). Another lab member, Alice Eldridge, applies machine listening in her applied ecoacoustic work. Collaborating with engineers, conservation biologists, geographers and anthropologists, she has carried out Leverhulme, H2020 and DEFRA funded research into acoustic approaches to biodiversity monitoring and wilderness mapping from Ecuadorian Amazon and cloud forests to Indonesian reefs and the Swedish Arctic. Her current work investigates next generation of analysis tools taking inspiration from experimental music and neuroscientific time-series analysis methods. In 2017 she organized the AHRC-funded research network *Humanising Algorithmic Listening*, see <http://www.algorithmiclistening.org>.

## 2.9 Performance

Most members of the lab are involved in musical performance as a method of research as well as emptying the mind. Through actual practising and performing, with the pre and post-concert discussions with organisers and audience is an important part of finding out the nature of a new instrument or a system. We observe users of our work in performance and learn from that. An example of such "stress testing" of feedback instruments is the *Brain Dead Ensemble*, The ensemble explores new concepts of shared, networked performance, where Magnusson feeds sounds from the Threnoscope into two feedback cellos and feedback bass [18]. Eldridge is currently commissioned by the ERC FluCoMa project to make new machine listening/ machine learning performance using their tools.

Other work includes Bright's *Passages of Time* (2016), with Chisato Minamimura, is a work that explores the deaf experience of music through dance. The score involved live processing of dancer's movement on-stage, electroacoustically processed Foley, and a live score performed using samplescapes and processed guitar. The sound design also featured extensive use of very low frequency, and the building of a vibrotactile interface to allow audience members to feel some of the sound cues.

## 2.10 Audiovisual Performance

In terms of audiovisual composition and performance, Andrew Duff and Alex Peverett have been developing digital and analogue visualisation systems for over two decades. Peverett's work explores generative digital processes as well as analogue video in the style of the Vasulkas, whereas Duff's work has recently focussed on vector graphics, visualising the sonic output of modular synthesisers through vector graphic matrix screens. Kiefer developed an audiovisual instrument using conceptors and machine learning (see '10k video' here <http://www.seeingsound.co.uk/2018-performances/>) and Magnusson's *Threnoscope* is an audiovisual live coding system. Ficarra's work continually applies video as part of the performance. Indeed, for many it does not make sense to separate the visual from the musical experience: sound, silence, image, colour, movement - all are time-based materials to be deployed compositionally.

## 2.11 Theory of Music Technologies

The Emute lab regularly organises research events on campus with an overall focus on the technological conditions of musical practice. This thread can be detected in lab members' work in various ways and Magnusson's *Sonic Writing* research project (with related book publication [16]) is a good example here. The project investigates the material conditions of musical practice, tracing genealogies through ancient Greek, medieval and early modernist thinking in order to build a grounded platform to understand future technologies of music making. Magnusson's work has a philosophical basis, whereas others might be rooted in different sciences, such as Eldridge's ecology and

cognitive science. For her hybrid techno-musicking operates in the space between cognitive science, conceptual art, and music composition and performance. She has explored generative music making and studies its parallels with Alife (simulation as opaque thought experiment) [6]. Bernardo's theoretical work situates at the intersection of innovation studies in music technology and creative industries [3] and human-centred machine learning. He investigates human-centred approaches to the design of toolkits to accelerate and broaden user innovation with interactive machine learning

## 2.12 Musical Robotics

Evelyn Ficarra spearheaded the Robot Opera Research Project at the Centre for Research in Opera and Music Theatre at Sussex, which has had two events so far: *Opera Takes a Robotic Turn* which considered issues of performance, embodiment and vocality, and *Robot Opera, What's Next?* which focused on theatrical and musical human/robot interaction (Figure 5). She collaborated with Ron Chrisley, director of the Centre for Cognitive Science and member of the Emute Lab. These human-non-human events have shown us our humanity through an unusual mirror. These events have typically ended with public symposia discussing the reality of non-humans in the performing arts, facilitated by theorists such as Prof Nicholas Till and Ron Chrisley.



Figure 5. From Ficarra's *Robot Opera, What's Next?* event

## 2.13 Music and AI

The main work in this domain at the lab is represented by the MIMIC (Musically Intelligent Machines Interacting Creatively) project. Bernardo worked on the RAPID-MIX project during his doctoral studies, and is now the postdoc on MIMIC. His research on the usability of machine learning technologies is implemented in the Sema system [2]. Kiefer's conceptual synthesis is applies AI technologies and Eldridge's ecoacoustics applies music information retrieval, and she is currently thinking about role of experimental and interactive music practices in "perceptualizing" large audio data sets to support interpretation of environmental data and public engagement.

## 2.14 New Notations

We have explored and developed non-standard notations for some time, ranging from common standard notation to live coding to graphics and animation. Magnusson's Threnoscope [15] is an example of a notation system in live coding, mixing prescriptive (here textual) with descriptive (here visual) notation. The Synchphonia project (<https://www.synchphonia.co.uk/>) has been developed by Hughes, Kiefer and Eldridge [8] aiming to help novice players to more easily follow notation in ensemble performance. Ulfarsson has worked with composers to explore new notational practices for his halldorphone instrument [19]. In addition to the Synchphonia project, Bright has worked on an AHRC-funded research project on new notations and we continue exploring this domain with our postgraduate students and through workshops. As an example, Ryan Ross Smith ran a workshop on animated notation with us a few years ago, a collaboration resulting

in his Study 57 composition featuring on the cover of Magnusson's *Sonic Writing* monograph published by Bloomsbury.

## 2.15 Modular Synthesizers and Audio Hardware

Andrew Duff has for many years researched and organised activities around modular synthesizers and related DIY culture. He and Derek Holzer, a guest workshop leader and performer at the Emute Lab 2 event, both incorporate handmade and modular electronic units with the performance of vector oscillographics whilst in parallel exploring media archaeological themes around reuse of obsolete and modified home games consoles and their technological wartime history going back to developments in radar (in Holzer's case), and additionally exploring past ideas of the future both visually and sonically (in Duff's work). Future explorations of modular synthesizers will be further exploring accessible audio and video synthesis as such techniques from the 1970s and 80s are being made more accessible through the development of reverse engineered circuits and shared information via online communities. Duff explores how and why these technologies appear to signify something 'futuristic', as devices, sounds and techniques are regularly reinvented, reused and resold. One of Duff's activities has been the organisation of the Brighton Modular Meet, where synth enthusiasts from around the world gather to demonstrate latest technologies, present research and perform.



Figure 6. Brighton Modular Meet on Sussex campus

Relatedly, Danny Bright and Lee Westwood have developed a part-composed, part-improvised performance system for two people, two pedalboards, and four amplifiers involving the re-appropriation of guitar effects pedals to create independent musical interfaces capable of generating and manipulating their own sounds.

## 2.16 Practice-based Media Archaeology

A considerable focus in the lab is media archaeological understanding of the music technologies. Watson has written about the role of the cybernetic ergonomics of the tape studio as shaping musical practices in the pre-digital studio [21]. Beattie is developing performance systems out of lathe cutters, inscribing sound directly onto vinyl during performance. Paul McConnell and Alex Peverett have worked on research into early personal computers, programming chips and working with languages such as BASIC and HyperCard. Common to all of these projects are the discovery of elements that have become implicit or tacit in our ways of working with digital technologies, but through the archaeological method are capable of revealing how certain decisions in the development of our technologies have been taken, why we have come to work in music in a certain way, shedding light on the evolution of certain musical tropes in contemporary music.

This work relates strongly to the theoretical media archaeological work by Sussex colleagues such as Ben Roberts and David Berry who are members of the Sussex Humanities Lab.

### 3. RESEARCH ENVIRONMENT

The Emute lab receives yearly funding from the School of Media, Film and Music to support research activities. It is also generously supported by the Sussex Humanities Lab which has offered spaces, equipment and technical support for various activities. Many of the Emute lab members are also members of the Sussex Humanities Lab and research and planning often overlaps. The lab also functions as a central research context for members of the lab when applying for research grants in this area, and the recent £1m MIMIC (Musically Intelligent Machines Interacting Creatively) AHRC research project and Magnusson's AHRC Leadership Fellowship are good examples of that. The lab is also part of the TENOR (Technologies for Music Notation and Representation) international research network together with Concordia, McGill, Georgia Tech, IRCAM, and more partners. The lab received direct funding from the TENOR network to run the MIMIC Summer School in live coding language design, see [www.emutelab.org/blog/summerworkshop](http://www.emutelab.org/blog/summerworkshop)

Other funded projects include Eldridge's AHRC-funded Humanising Algorithmic Listening Network and Kiefer's British Academy Rising Star Designing Interfaces for Creativity project. The NETEM project that resulted in the Synchponia app for realtime note following in musical education was funded by the AHRC and so was its follow-on grant that enabled the researchers to put the application onto app stores. These are examples of the type of funding that supports the activities of the lab.

### 4. EVENT ORGANISATION

In 2016 lab members organised the third ICLI (International Conference on Live Interfaces) conference at Sussex. It took place in the newly renovated Attenborough Centre for the Creative Arts on the Sussex campus, as well as on various locations across the city. The paper proceedings and video documentation can be found on the conference website: <http://www.liveinterfaces.org/2016>

The lab regularly organises symposia and workshops in theoretical and practical matters from ecoacoustics to live coding language design. All of these events are open to the public, other researchers and our students. This public engagement also takes the form of organising concerts and gigs in various locations, and we have built a lasting relationship with the Rose Hill music venue and arts hub in central Brighton. As part of Magnusson's AHRC fellowship in 2016, he organised the Musical Organics symposium on new instrument design at STEIM ([www.sonicwriting.org/steim.html](http://www.sonicwriting.org/steim.html)) and the New Notations symposium at IRCAM ([www.sonicwriting.org/ircam.html](http://www.sonicwriting.org/ircam.html)) on new musical notations for intelligent instruments.

Recent workshops include the FACT/// symposium for feminist computational work (<http://fact.network>), the MIMIC summer school in live coding performance and language design for machine learning (<http://www.emutelab.org/blog/summerworkshop>) and the musical materialities workshop (<http://www.emutelab.org/blog/materialities>).

### 5. FUTURE VISION

A research laboratory in the arts is not a physical space or a collection of equipment: it is rather the sum of relationships and activities that emerge when people work collaboratively on common projects. As such, a lab can be informal, dynamic and spontaneous set of activities that emerge around common interests. A research lab is an umbrella of activities that appear under an identity, and people who have been involved with industry collaboration or grant applications know how important such an identity can be. We have resisted the idea of turning the lab into a university wide research centre, which would involve a more formal top-down approach with boards and operational scrutiny, and sought to keep the spirit one of bottom-up project-driven collaborations based on shared enthusiasm and vision of what future musical practice research might be and might become.

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