Raw Data, Rough Mix: Towards an Integrated Practice of Making, Performance and Pedagogy

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ABSTRACT

This paper describes an extended intercontinental collaboration between multiple artists, institutions, and their publics, to develop an integrated musical practice which combines experimental making, performance, and pedagogy. We build on contributions to NIME which work with art and design-led methods to explore alternatives to, for example, more engineering-oriented approaches, without loss of practical utility and theoretical potential. We describe two week-long workshop-residencies and three performance-installations done under the provocative title Raw Data, Rough Mix which was intended to encourage exploration of basic processes in physical, mechanical, electrical, electronic and computational domains to develop musical artefacts that were frugal in their resource-demands but enabled the interrogation of human/non-human relationships, performativity, musical ecologies, aesthetics, and other matters. We close by elaborating our contribution to NIME as offering an integrated practice combining making, playing and learning, which is critically informed and practically productive.

Author Keywords

Collaboration, experimental interfaces, music hardware, music performance, Research through Art and Design, annotated portfolio, pedagogy

CCS Concepts

• **H.5.5 [Information Interfaces and Presentation] Sound and Music Computing.**

1. INTRODUCTION

This paper describes a three-year collaboration involving artists, researchers, and students from two continents. Our work combines experimental making with public performance-installation [14, 15] and has begun to develop a characteristic pedagogy which goes beyond many traditional teaching and workshop approaches. We aim to create an integrated practice combining artistic research, making, performance, and learning, which emphasises materials exploration, incremental experimentation, and critical music making, while balancing collaborative and individual-autonomous work.

Our work develops contributions to NIME which draw on 'Research through Art and Design' (RtAD) an approach with a 20 year history in Human Computer Interaction and allied fields [24, 25]. RtAD emphasises making as a means of exploring research issues, particularly at the intersection of research fields or disciplines. 'Makes' are a means for developing insight rather than as a test of a pre-existing theoretical framework from which the instrument, interface, artefact, or whatever is derived. As such, the RtAD approach offers an alternative orientation to engineering methods or experimental methods derived from psychological research which, say, develop specifications on the basis of theoretical deliberation or investigation of user needs. In NIME, we [22] introduced the idea of 'curated research' whereby researchers proliferate responses to a selected research theme. A collective of researcher-artists worked in response to 'one knob to rule them all' exploring issues in interaction design of relevance to NIME. On similar grounds, Bowers, Shaw and Bowen [5] name their approach 'many makings', emphasising the exploration of a number of makes rapidly and in parallel. In both [22] and [5], the collection of makes is gathered into exhibitable/performable work and reflected on as an 'annotated portfolio' [2] to speak to research issues.

This work (and see also [6]) emphasises a light touch to making. Participants proceed intuitively and explore possibilities to varying levels of sophistication. Consistency is not required and participants can move freely between collaboration and pursuing individual interests. The 10000 Instruments Workshop at NIME 2020 [9] was conducted in a similar spirit. Many proposals were generated for instruments, some practically viable, some facetious, some to provoke critical reflection on contemporary culture. Amongst other issues, the workshop convenors considered how this light touch creative approach can have a certain kind of pedagogical value [9]. The workshop was not organised around the imparting of knowledge from the pedagogue to the students, as many are, but as creating an arena for collective action with the convenors and the attendees as co-participants able to learn from each

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other equally. Similarly, Marquez-Borbon and Martinez-Avila [21] call for performance-based 'non-traditional' pedagogies as a means for creating communities, performance practices, and addressing the often noted lack of uptake for the devices created within NIME [23]. Our work seeks to build on this emerging theme of self-organised learning and pedagogy which treats nominal teachers and learners as intellectual equals [29] in a co-participatory environment [7, 12, 10].

In addition to beginning to develop a characteristic pedagogy, the current work engages with criticisms that are sometimes lodged against art and design-led research [e.g. 20]. For example, it is remarked that such work is rarely cumulative but sometimes just seems to be a collection of interesting but unrelated artefacts. In earlier work [22], we identified 'Raw data/raw sound' as one of five annotations that characterised a number of makes in that project. In the work we report here, this became the basis for a new provocation to thematise our making. In this way, we attempt to build upon existing work thematically but without loss of creative flexibility. The rest of this paper describes the things we made, and how making them related to forms of performance and learning, and informs our attempt at an integrative NIME practice.

2. RAW DATA, ROUGH MIX

One emergent preoccupation of our making is with the character of raw materials and creating artefacts, devices or instruments which stay close to the materials of which they are made. The idea of 'rawness' is suggestive. We can think of raw materials but also raw data, raw meat and raw electricity which encourage us to think of aesthetically brutal approaches, respectively, to using sensor data or sonification techniques, to implicating the body in performance environments, and to explore low component count methods for sound synthesis. In English, raw is pronounced identically to 'roar' - and we can imagine some of the things we make as extending the call of an animal into non-animal, mineral, and electro-magnetic ontologies.

We decided to elaborate on the idea of 'rawness' through creative retreats in which a group of invited artists and/or researchers would work in response to the brief Raw Data, Rough Mix (RDRM) to create a large number of small works. These works would then be drawn together into performance-installations. The retreats would continue a trajectory of creative research which explored the value of working with a light touch in a compressed period of time, and thorough reflection on what is made, to draw out implications for how we think about contemporary performance, artistic technologies, and the very nature of making.

Our past explorations have also worked with an idea of 'assemblage' [49, 50]: things, often made of very different materials and with very varied sonic characters that are put together in and through performance. On retreat, we intended to think expansively about assemblage and how materially heterogeneous artefacts could be made to inter-work, and to explore different topologies (networks, fields of influence, layers, overlaps) and different performance practices (varied patterns of coordination, scored and improvised).

Taking our research on tour as it were, we gathered a network of like-minded folk from different institutions in the UK and Japan. RDRM consisted of two week-long workshop-residencies – Allenheads Contemporary Arts (UK) and Tama Art University (Japan), and three performance-installations – Reactor (Nottingham), Cafe OTO (London), and Ochiai-Soup (Tokyo).

Our creative retreats and performances combined established artists/teachers/researchers with post-graduate students. A total of 15 participants had some presence in the project. Five individuals had University positions and well-developed creative practices. Three participants were students engaged in PhD research. Seven students engaged in Masters-level study joined us in the residency in Japan.

Our retreats combined a number of formats. For example, we might jointly explore a minimal design or set of materials proposed by one of the participants. Another possibility would be to engage in focussed archival research to reexamine historical or personal work from a RDRM perspective. Some work involved taking commercial devices and hacking them out of their comfort zone. Participants were also free to bring in their existing projects and see if they could be given a RDRM influence. Rarely did we make anything to a pre-established schematic or recipe, and we would replan throughout. While some activities provided a collective focus and were done together, there was no prohibition on autonomous individual work done in the presence of other participants.

3. OUR MAKINGS

In this section we describe the most significant makes which emerged over the course of our work. We have been deliberately inclusive here, albeit at the cost of some depth of description, to give an impression of the variety of work. Some makes are minimally specified domains for incremental exploration. Some are small synthesizers. Some are 'hijacked' commercial, or otherwise, 'found' objects, bent to our interests. Some are explorations of fundamental physical phenomena. Some are electronic circuits capable of a variety of behaviours and uses. Some involve a degree of technical care in their making, while others are more 'poetic' in their motivation. Some provoked discussion and elaboration amongst participants, while others served more as a finite demonstration of a design idea. Each make responded to the provocation RDRM, though, as we will see, in a divergent number of ways.

The Victorian Synthesizer

The Victorian Synthesizer [43] is an exercise which starts with just a battery (up to 9 volts), a loudspeaker, and a collection of crocodile cables. It is observed how clicks can be made by connecting the battery across the loudspeaker terminals. Other materials are introduced, for example, washers, coins or nails bouncing around in the speaker cone acting as momentary switches, a sample of conductive metal whose texture can be heard by moving a croc'ed nail across its surface, basic components such as tilt switches, and so forth. An anemometer consisting of a circular array of reed switches was croc'ed in so that its turns could be heard. The overall sound of the speaker could be shaped by experiments with cardboard enclosures and resting it on resonant objects. Participants also experimented with two speakers interacting (e.g. with one making and breaking the circuit of the other) and how a Victorian Synthesizer could interact with other devices. In addition to experimentation with minimal electric sound, The Victorian Synthesizer served as an occasion for discussing the history of the loudspeaker, the dependency of electronic music on them, the non-neutrality of loudspeakers in the shaping of sound, and their potential as raw, rough instruments that could be fashioned from salvaged artefacts and materials.

Figure 1a,b,c. The Victorian Synthesizer

Ohm-My-God

Ohm-My-God [44] investigates ad hoc mixtures of basic components where chance connections create arbitrary circuitry. Two electrode plates are placed into, say, a kitchen bowl with each plate connected to a low voltage battery terminal. Arbitrary components can be added: resistors, capacitors, transistors, diodes, lengths of bare wire. The current at selected spots of the mixture is sampled with a conductive probe and amplified. Different sounds are made as spontaneous circuits make and unmake themselves as components settle under gravity or are manipulated. Noises and crackles are common but occasionally a random oscillator will form.

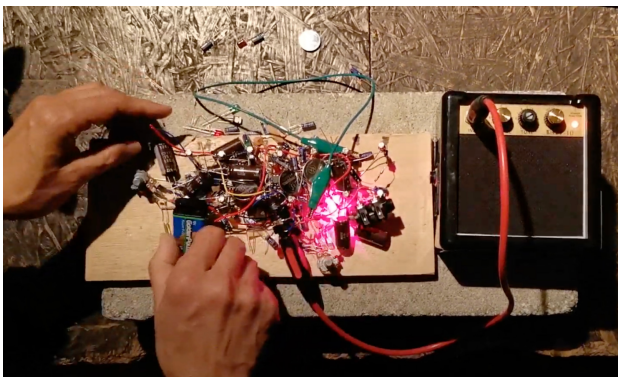

Figure 2. Ohm-My-God and Bad Buffer

Bad Buffer

Bad Buffer (Fig 3) is an interface, a go-betweener, making raw current and voltages usable in different contexts. Its raison d'être is compatibility, yet often with a perverted twist. It is not only a buffer but shaper of signals. Control voltages or audio signals can be amplified, clamped, clipped, offset and inverted. And with extreme overdrive and DC offset, it can be 'bad' [46]. During the residency at Tama Art University, Bad Buffer was made using dirty electronics-style breadboarding: wood base, nail terminals and wire-wrapped construction. This construction technique, aside from its prototypic nature, has pedagogical benefits as we shall discuss. Bad Buffer became a focus for workshopping and collaborative making, and an interface for our inter-work. Its uses were open-ended: no-input feedback, guitar and monochord overdrive, Ohm-My-God signal buffer, and Motor Music (see below) waveshaper.

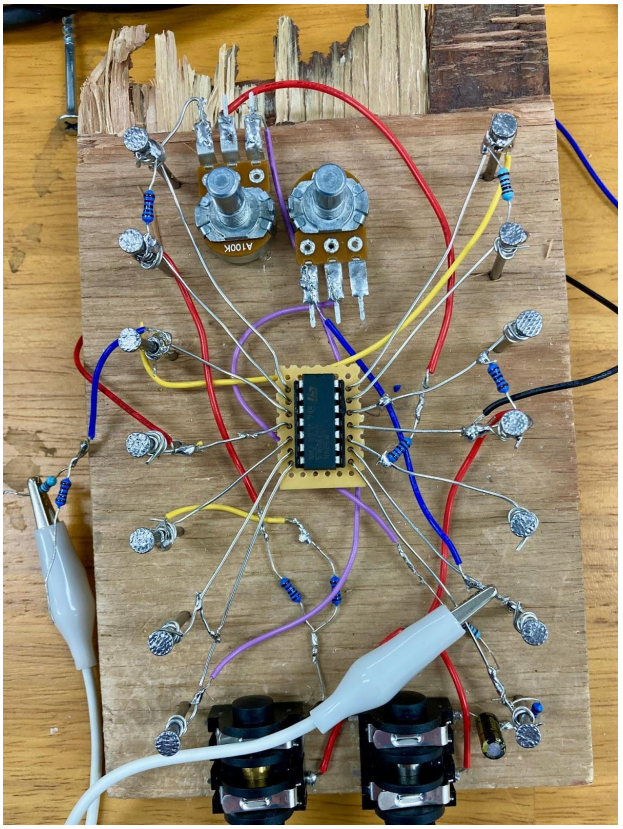

Figure 3. Bad Buffer.

Power Rail

Power Rail, again a wood and nail construction, falls into the same category as Bad Buffer. It is a mini DIY interface to 'cook' current and voltages. Power Rail has multiple features. A bridge rectifier and voltage regulator, and parallel wire rails from which capacitors can be hung to smooth current or hold a charge. The charge and discharge of capacitors provide a time-variable parameter related to current. A frugal interface, yet with many uses, for example, control voltages derived from motors and Clickers or used with the Radical Nails and Floating Noise (see below).

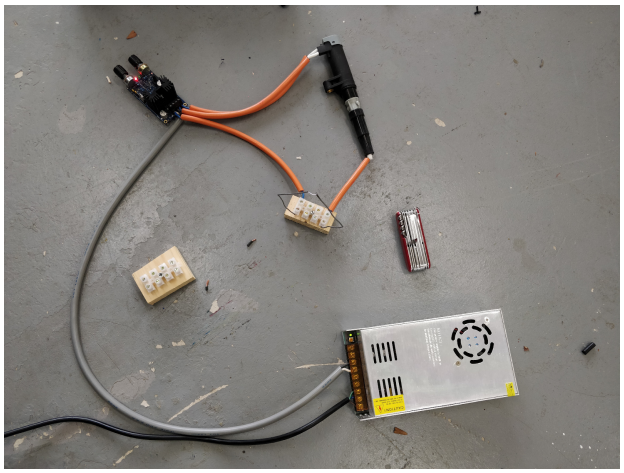

Figure 4. PWM Sparks

Spark Gaps

Simple spark gap circuits were constructed using a Marx Generator to create a high voltage pulse from a 9-volt battery [13]. These pulses of sound and light can be performed and spatialised in various ways. A single circuit can be played by placing chopsticks between the electrodes to generate variation and moved around the room to create spatial fluctuation. When working with multiple circuits, devices can be placed around the performance space to form an omnidirectional impulse texture. As these circuits give out a large electromagnetic field (EMF) when two or more spark gaps are placed close to one another, complex interactions can occur. These fields could also be explored using a collection of radios. As the power from the battery slowly drains, the pulses become more irregular, creating an unforced compositional arc.

Marx Generators were modified further with the use of two large aluminium sheets, scavenged from a skip. These were suspended using fishing line, and adapted to become electrodes. Left to swing, contact between the sheets caused sparks. An electric fan was used to move the plates leading to indeterminate sparking.

Jacob's Ladder

A Jacob's Ladder, involving two protruding electrodes mounted on a piece of scrap wood, was created using an old neon-sign transformer. When powered, a high voltage electrical arc moves up between the protruding electrodes, dispersing light, sound and an EMF. The speed and regularity of this movement is determined by environmental factors such as the temperature and humidity. This construction can be left to run autonomously or interacted with using other high voltage devices.

Figure 5. Modified Marx Generators

PWM Sparks

Another high voltage spark gap was designed using a spark coil and a PWM pulse generator. Generating high voltage with square wave modulation creates a more controllable spark gap. By increasing the frequency and pulse width of the square wave, different tones and textures can be achieved. The large EMF can also be listened to through radios, coils and other electromagnetically sensitive devices.

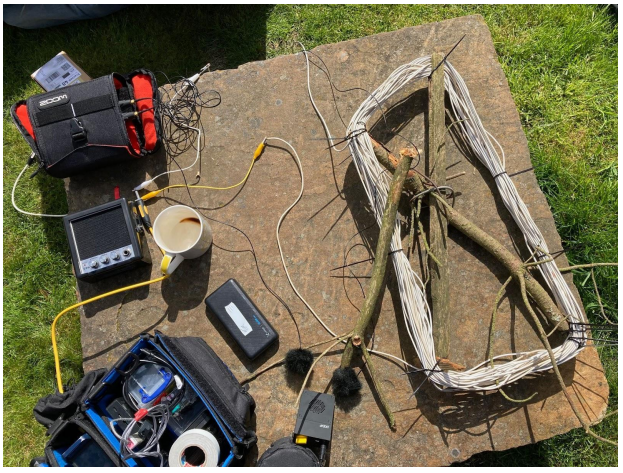

Figure 6. DIY ULF Aerial

Other Electrical and Electro-magnetic Phenomena

In Earth Synthesizer two electrodes of dissimilar metal are inserted into the ground to create a 'telluric battery' and

connected to a high gain preamplifier, e.g. Bad Buffer in one of its configurations.

DIY Aerials were made by turning insulated wire around a frame of found wood to create a ULF aerial sensitive to atmospheric storms and other electro-magnetic activity which can be made audible through amplification.

A Hapless Roar

A Hapless Roar is the name of a room feedback system [45]. In this, microphones pick up room sound passing it to a patch in Pure Data (https://puredata.info/) which offers multiple parallel processes before passing it back to the room. The processes include short delays, resonant filters, distortions, granularisations, frequency shifts, FFTs which smear and freeze, delay lines which are tuned by analysis of the dominant partials of the current room, amongst several others. These processes can have the amplitude of their contribution mixed and each has a dominant parameter that can be played. While the system can autonomously create a variety of room feedback tones, its behaviour is also dependent on and influenced by whatever sound originates in the room.

Motor Music

When a DC or AC motor is plugged into a mixing desk or connected directly to a speaker and the shaft is turned, electric current and a waveform is produced. This current can be used to directly drive a loudspeaker or amplified. Motor Music questions what we might consider a musical instrument or interface. The sound and instrumental potential of the motor exist latent in the device. There is an onus on finding and revealing sound through the process of amplification. Another 'hidden' sound of the motor derives from its electromagnetism. When amplified, it makes a great pick-up. Motors can be tapped or rubbed against each other or other things to make sound. They have microphonic properties. They can be used to 'sniff' other electromagnetic fields resulting in, for example, pulses, hisses, whoops and assorted noise. At Allenheads Contemporary Arts, a collection of motors from, for example, old printers, scanners, and CD players were categorised and their sound documented. The motors lent themselves to rummaging (see Rummaging).

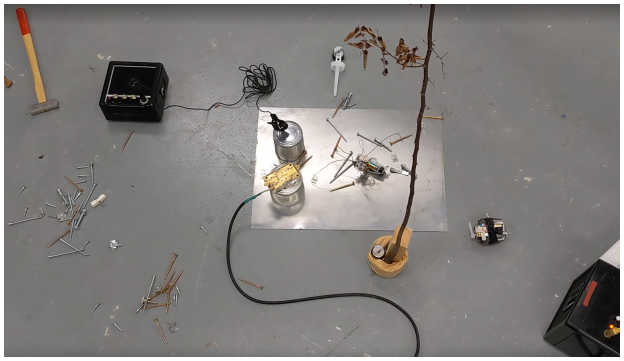

Figure 7. Motor Garden

Motor Garden

Motor Garden explores the motor as a sound making device, taking its cue from similar motor-based work the group had undertaken (see Motor Music). Initially, the Garden consisted of small 3-volt vibration motors attached to coin cell battery packs. These were placed inside upturned tin cans causing them to jitter and wander across the floor unpredictably.

Further devices were built using scavenged materials with the self-imposed restraint of being made from a single motor, for example: a motor attached to fishing wire suspended above a snare drum to produce an uneven buzz roll that could be further performed by muting the drum with other objects or by releasing and applying the snare; a branch wedged into a tin can that would vibrate and quiver across the floor; a miniature cowbell attached to a geared motor with a low RPM to create its own limping percussive accompaniment; a similar motor attached to twisted strands of wire that rolled drunkenly into other objects.

Motors mounted on makeshift stands had wires attached to their axles, and various objects – wires, rubber gloves – could be attached to these. These devices were used to 'play' strings or other objects.

Rummaging

Rummaging is a way of making an acoustic noise music with the hands using objects often scavenged from performance sites. The character of the performance is therefore dependent on the environment and provides a way to interrogate environments through performance in a manner that complemented the group's work, where scavenged items were often brought from outside to be performed with and used in larger assemblages.

Three videos were made to capture this work. In the first, the remains of a sheep's skeleton was found on an exposed hillside near Allenheads Contemporary Arts. The collection of bones was rummaged in situ. The second used a discarded ceramic basin found by the side of the road as a rummaging container, and items collected throughout the residency were performed with. The third was made at Tama Art University in a skip filled with scrap metal. Contact microphones were attached to the sides of the skip to capture its resonance as the metal was rummaged, and a GoPro camera was fixed to a vantage point above the container. Each video work was imbued with the character of its environment: the mud, bones and windy hillside, the items in the basin, the scrap metal in the skip.

Figure 8. Rummaging box

String Instruments

Mono-chords were made by suspending guitar strings across lengths of PVC piping. These could be played acoustically, or electronically amplified using a contact microphone or pickup. Designs with electromagnetic actuation were also explored using a powered electromagnet and an oscillator tuned to the

frequency of the string as an input signal. This design allowed other sound-making devices to be 'played' through the string. Feedback was also explored as an actuation signal, and routing the contact microphone into the electromagnet created unstable and ever-changing feedback. Designs with multiple strings were explored, some with their strings entangled to create 'webs'. These instruments created a sympathetic resonance of the other sonic activities in the space, connecting them to the immediate sound environment.

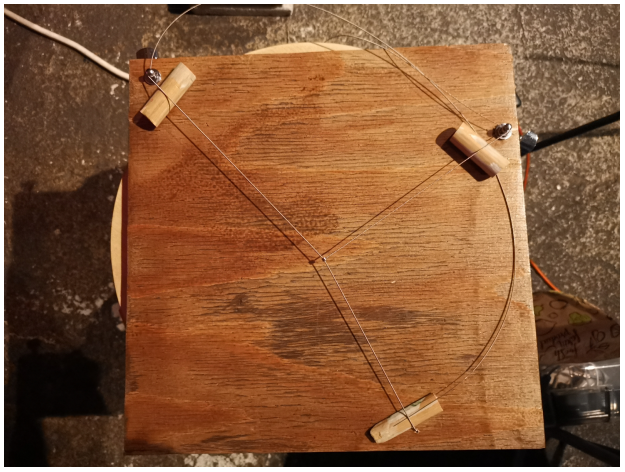

Figure 9. A two string, three string segment String Gong.

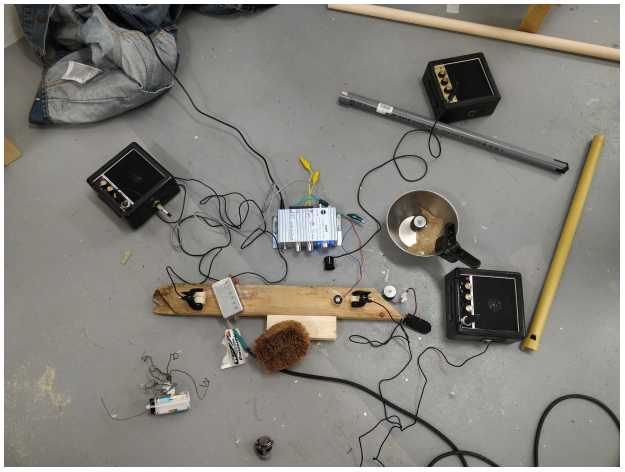

Figure 10. Monochord

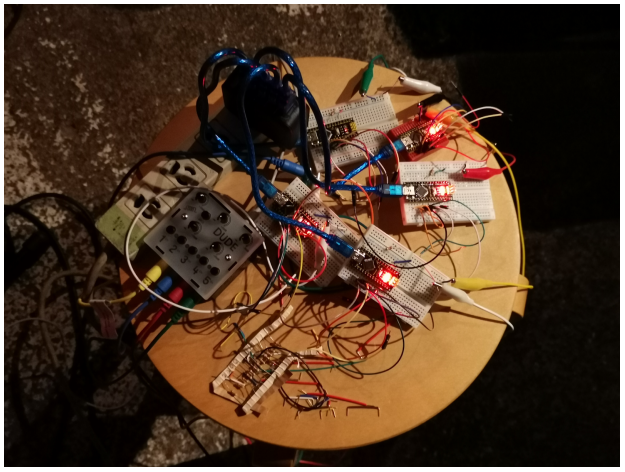

Figure 11. Five different versions of Floating Noise

Floating Noise

Floating Noise attempts to bring the philosophy of incremental experimentation on a minimal base, manifest in The Victorian Synthesizer and Ohm-My-God, to the domain of digital synthesis. A minimal synthesizer was coded for Arduino with a PWM output as an audio signal to a battery powered amplifier. The design had no external circuitry save bare jumper wires floating in the analog-ins. These could be touched or brought together or connected to the supply voltage or ground. The boards were exposed so the ICSP pin block and the ATmega chip itself could also be touched. The code used the tone command with values sent to it computed from expressions combining the analog-in readings. We provided a number of specimen formulae which generated quite different sounds and exhibited different forms of responsiveness to touch. We also inserted some dummy lines of code (e.g. a loop in which an unused variable was filled with a random number) which effected the speed of the main program loop - and hence the behaviour of the synthesizer (not just its pitch). Participants were encouraged to find their own formulae and lines of dummy code. Not only did we collectively find a great variety of sounds, Floating Noise engendered discussions about how hardware and software interact, the sensitivity of computational devices to 'outside' influences, and how standard electronics practices (such as pull-up resistors and earthing floating connections) configure the otherwise uncontrolled tendencies of processors.

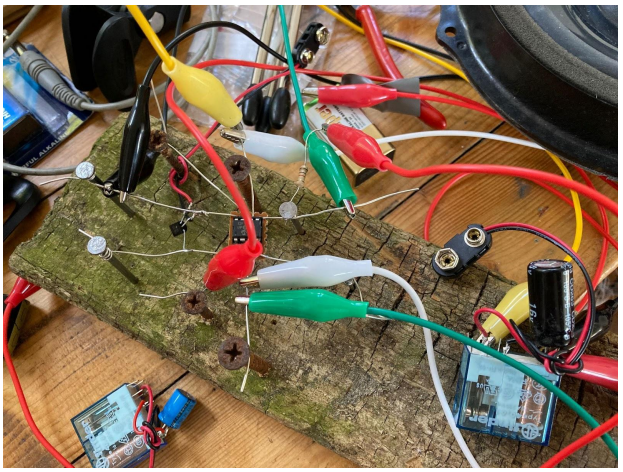

Figure 12. Radical Nails/DAC-less Synth and Clickers (mechanical oscillators made from a relay, capacitor and battery)

Radical Nails/DAC-less Synth

The Radical Nails – a low-cost wavetable synth for 8-bit 8-pin Flash Microcontroller using direct digital synthesis (DDS) techniques – was used as a point of departure for reductionist and frugal innovation [19]. While at Allenheads Contemporary Arts, frugality was extended to all aspects of the synth's hardware. Aside from the Microcontroller, hardware materials were found locally: wood and old screws and nails from a derelict barn. Analogue inputs were left floating and the simple RC filter and DAC, found in earlier iterations of the synth, was removed. The 5-volt regulator for the Microcontroller would also be discarded at a later date and the synth powered at 4.5 volts – 'raw' sound as PWM data.

The synth is played by touching the nail and screw terminals, or patching crocodile cables, resistors and capacitors to the open wire structure.

Raw Data Synthesizers

A number of simple programs were made in Pure Data to explore (raw, rough) ways of transforming arbitrary streams of data into sound. These included: synthesizers which read data into wavetables and use a principle of fractal expansion [cf. 22] to develop oscillators or rhythm generators that exhibit self-similar behaviour over different timescales, a drone machine which uses ratios between successive data to create continually shifting intonations [cf. 41], a synthesizer which derives its wavetable entries and sequencer values from ASCII text and timing data from qwerty key presses, a synthesizer which derives its wavetable from knob movement on a commercial MIDI controller and uses another knob to play the wavetable via a continually shifting transfer function, a program which swamps a selected commercial synthesizer (Kong NTS-1) with MIDI data so that its most familiar sounds become unrecognisable.

The Haganator and The Raw Data Rough Mix Megasynth

These two synthesizers coded in Pure Data explored different conjectures concerning the foundations of musical sound, some with a tongue-in-cheek character, together with 'low-level' methods for transforming sonic input. The Haganator elaborates on composer Kerry Hagan's work who suggests, following Iannis Xenakis, that glissandi can be regarded as raw materials for composition. In The Haganator, the start and end frequencies of glissandi, their duration and waveshape, are all determined by logistic map functions [42]. This enables a variety of noises, modulations, and pseudo-sequences to be realised. The Raw Data Rough Mix Megasynth explored 8 methods in parallel for synthesising sound from restricted numbers of basic Pure Data objects. For example, highly reduced versions of waveguide and pulsar synthesis were available alongside an implementation of waveset synthesis to create pitch shifts and time stretches.

4. MONSTROUS ASSEMBLAGES

In RDRM we presented our work three times to the general public at different venues. These showings have the character of part-performance, part-installation. We try to be maximally inclusive, offering opportunities for as many of our makes as possible to feature. We give our work a kind of gathering [4] or assemblage [49, 50] format where a variety of different things are on show, organised so that relationships of similarity and difference can be explored. Like our makings, our performances are entangled. Devices are setup in networks that are responsive to other devices, and performed with and against other performers. We improvise guided by a principle we associate with David Tudor "to discover and disclose", in an unhurried fashion, what our makes are capable of doing – a way of working which contrasts with some orientations where the instruments are seen as the means for human expression [40]. There is not always the explicit desire to control our instruments or interfaces but to adopt a relational position to autonomous sound. This may take the form of attending to, rather than 'performing' with our sound devices and instruments [14]. We arrange our work around the performance-exhibition space and prefer no fixed separation of a 'stage' area. In this way, the audience can inspect our work close-to and move around as the performance unfolds. The intent is to create an 'ecology' of making, playing, and listening. We work with an approximate outline performance schedule. One of our events was organised around three moods/intensities – Gentle, Noisy, Exhaustion – but with flexibility as to how these should be realised. For example, the performance finished with an intimate episode of Ohm-My-God and Bad Buffer spluttering into a small battery powered amplifier with the audience gathered close around. Along the way, as a natural feature of our creative residencies, we have gathered in the same spirit as new work emerged. At Allenheads Contemporary Arts, we had private performances each night. And on the final day at Tama Art University, we staged an open-studio with all our work on show to visitors from the University.

5. AN ANNOTATED PORTFOLIO

To reflect on what we have presented so far, we follow Bowers and Gaver's concept of an 'annotated portfolio' [2, 27] as a means for exploring the implications of art and design-led research. We concentrate on how annotations can map the relationships in a body of work and speak to themes of general interest. We also show how the work we have described builds on past research in a cumulative fashion.

We offer four annotations, each one as a suggestive elaboration of one of the constituent terms in 'Rough Data, Raw Mix'.

• *The Raw is Pre-Cooked.* All 'raw' materials come to us pre-made or pre-shaped to some degree [cf. 11]. Electronic components are manufactured with selected values and tolerances. In our work with electronic sound at a fundamental level, current and voltage are still pre-cooked in many ways by, for example, a smoothing cap or the resistance of the wire which carries the signal. This is notable in Motor Music, Ohm-My-God and The Victorian Synthesizer. In Spark Gap and its variants, the current, voltage and the gap between the electrodes are all critical details to 'pre-cook' different sonic results. Even the earth is a product of much pre-working (sedimented decomposition, humus) and metals and minerals are mined, extracted, purified. Similarly, computational environments come configured with already existing commitments as Floating Noise makes plain.

• *Data are Capta.* No datum is innocent. What is available to us as data is already captured, shaped, measured within an apparatus [1]. Obtaining 'good' data may require special measures and techniques (pull-up resistors, floating pins earthed, appropriate sample rates) as Floating Noise shows by dramatising what happens without them. While much NIME research is concerned with optimal means for mapping data, we created eminently playable small synthesizers while being very crude about this issue – including one that perversely used input data to rewrite its own transfer function.

• *The Rough and The Smooth.* The clumsy and the careful, the artful and the artless, together, juxtaposed. Coarse and fine gestures. Some of our makes, especially those exploring high voltages, require careful, occasional intervention and distanced oversight from the performer. In contrast, Rummaging often builds to frenetic action. Our room feedback system, A Hapless Roar offers both rough and smooth possibilities algorithmically and interactively. A short delay or a spectral freeze can mix the sounds adding to their central tendency while a heavily randomised sparse granularisation may make the mix crackle. In addition, while some of our approaches to making may seem rough and boisterous (arbitrary combinations of components or materials), others seem (at least metaphorically) smooth and carefully crafted (circuit design, programming).

• *Zones of Entanglement.* Rather than enforcing a harmony on our different contributions, we have preferred promiscuous mixtures of materials, soundworlds, interaction methods and so forth. Our mixes 'curdle' to use the image of postcolonial philosopher Maria Lugones [26]. Or, to use a related metaphor, our constituents entangle [1, 4] with each other rather than interact in ways conceptualised as dataflow from source to

destination. Interfaces such as Bad Buffer and Power Rail encourage entanglement at an instrumental or device level. Things can be patched together ad hoc. Single sound-makers are interconnected to form complex networks. Audio signals and control voltages become entangled. Rummaging essentially occurs through physical entanglement between human and non-human elements. Similar tangled relationships exist within our overall practice where, for example, students, researchers, independent artists work together, become entangled in each other's concerns without any necessary 'flow' of information or instruction between them.

6. PEDAGOGY THROUGH MAKING

There is limited space here for empirical analysis of what our student-participants did during the course of RDRM. But let us make a few observations before offering some larger speculations for NIME pedagogy. We regard the makes as collaboratively emerging from participants. Several of the activities were seeded by participants with prior experience of similar work but in each case new inflections and adaptations were found. Even work developed by single individuals was shaped by others and the overall concerns of RDRM. Indeed, several 'anonymous' devices – some salvaged from other broken makes – appeared amongst the collection of things built at Tama Art University.

Several of our makes served as ad hoc occasions for further discussions about music, art, physics, and philosophical and cultural critical ideas. For example, the various Raw Data synthesizers engendered discussions about chaos theory and other physical-mathematical topics for their relevance in coding sound. These topics arose not as matters of instruction but through practical encounters in making.

We left many of our makes open and responsive to the dynamism of the group. Participants' own practices and interests were folded into the concept of RDRM. For example, one participant used a bucket of slime to control a Bad Buffer feedback circuit. Another took the monochord idea and built other circuits of interest into the body of the instrument, creating a hybrid embodying responses to several of the activities of the residency.

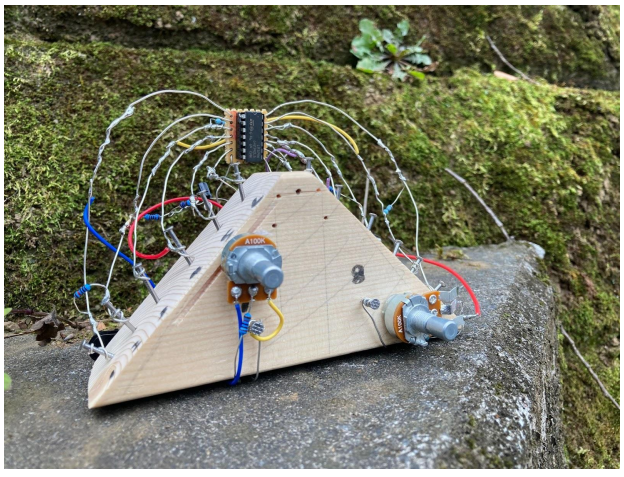

Figure 13. Sculptural realisation of Bad Buffer by Chen Yixuan.

Bad Buffer and its construction method using wire-wrapping and point-to-point connections provided a vehicle to learn about signal flow and practical electronics. More specifically, the method illustrated the relationship between abstraction (schema/schematic) and physical circuits (layout) [18]. The hands-on approach also brought different disciplines together. Sculptors amongst the participants were able to 'craft' the wire-wrapped and found wooden-base structure of the Bad Buffer into visual artworks in their own right.

At NIME 2011, a workshop called for efforts devoted to NIME education. However, in over 2000 papers in the NIME Archive, fewer than 30 give explicit principal attention to pedagogy or allied matters. While we do not have space here to do a thorough critical examination, a number of themes in this literature can be extracted by way of 'pocket review'.

In this small corpus in NIME, it is common to read of work developing technologies to support existing pedagogical practices or convey existing musical topics [30, 31, 32, 33] rather than engaging in design and making as the pedagogical topic itself. Sometimes, a pre-existing artefact is explored that allows limited peripheral design work from participants [34]. Where participants do create their own artefacts, activities are often organised around imparting basic generic skills before novel projects are initiated [35, 36] Sometimes, a restricted fixed common toolkit is presented to participants [37, 38]. Particular instrumental paradigms (notably hyper- and augmented instruments) can be preferred in the belief that these separate and highlight core issues [37, 39]. Making activities are often organised around a design or musical challenge set by the pedagogue [36, 38]. Overall, making is often conceived as a goal-oriented activity where something 'finished' is the aim and where success in meeting that aim can be assessed or at least critically reflected upon [37].

Examples of alternative pedagogy emphasising improvisation and exploration are beginning to emerge [21, 48]. To add to this, we feel our work, with its emphasis on developing an integrative collaborative practice of research, experimental making, performance and learning offers a radical participatory development that is worth contrasting point-by-point with the pocket review of the previous paragraph.

1. Pedagogy through Making. We take exploring materials for their musical potential and making a variety of artefacts as the primary focus. Just as, according to RtAD, it is out of making that research value comes, we wish to explore possibilities for pedagogical value to emerge from concerted making.

2. Rawness, fundamentals. Little in our activities is built to a fixed recipe or limits participant modification. We move closer to 'raw' materials and fundamental ideas in electronics and coding, building from these rather than instantiating an existing design.

3. Skills as required. We do not require participants to be initiated via basic skills. We prefer to find activities which are already creatively productive without new skills being needed. Those skills, basic or otherwise, can be addressed as and when work requires it.

4. Range of possibility. No particular instrumental paradigm is mandated. Hyper-instruments are welcome but, to indicate the breadth of possibility, so are 'infra-instruments' [3, 22] and the forms of material-oriented interaction discussed in [47].

5. Divergent interpretations of a provocative theme. No particular challenge or goal is set. A provocative theme might be selected but this is deliberately articulated to be expansive, allowing many different interpretations [6, 22].

6. Openness. Makes which are unfinished, exist only as proposals or performances, are open-ended, or 'open-beginninged' [9] are all encouraged. The ideal of a

product-approximating device or artefact which solves problems or fulfils a function is withheld [9].

7. CONCLUSION

We have described our development of a creative practice which encompasses exploratory making, public presentation through performance-installation, while supporting a kind of radical participatory pedagogy. For us, making, performance, and pedagogy can be different aspects of a common process *provided each is realised to favour an open, exploratory, and convivial ethic where multiple interpretations and values can coexist* [28]. To explore this possibility, we worked with a shared provocation built upon prior research. We hope to have given a hint of how developing such practices can not only help enrich research themes in NIME but also exemplify the kind of community-sustained extended practice Marquez-Borbon and Martinez-Avila [21] call for – a practice which is often disrupted by ideologies of innovation, commercialism, and cultural normativity. Our work also takes a step outside the conventional demands of curriculum development, evaluation, and individualised assessment that contemporary teaching institutions often impose [cf. 48] to initiate a more fundamental discussion of pedagogy and its relation to artistic work, technical development, and public performance.

In the abstract to this paper, we characterised our methods as 'alternatives' to 'more engineering-oriented approaches'. A full discussion of methodology and the different philosophies in play in different disciplines is way beyond the scope of this paper. But let us make a few remarks here. When we write of 'alternatives', we are not intending our methods to ubiquitously supplant all others. It is not our contention that research which operates with a careful iterative cycle of analysis, requirements, development, evaluation, refinement et cetera should necessarily be abandoned in favour of what we do. Nor do we think that our methods of annotating a portfolio of makes and exploring those annotations in further creative work is preferable in all contexts to, for example, forms of hypothesis testing, generalisation, and theory building. Besides, we are often dependent on the work of others who might have quite different orientations to making from ours. We do not dispute the engineering of the electronic components we use nor seek to break the Pure Data programming language. Any make will be a composite of (pre-existing) things we use and (new) things we do. Methods exist as alternatives, to be sure, but neither in an exclusionary fashion nor always in a mutually consistent one. What matters is how combinations of ways of doing are configured, what is apt for different settings, and what value there might be in the tensions that arise.

We feel that our approach serves well to explore a broad range of design possibilities and hence gain an impression of what the larger 'design space' might be. This is especially valuable when new research topics are in the air and when there are valid choices between many different ways of proceeding. We are less suited to scenarios where there is a well articulated problem that needs solution. Our approach has advantages when divergence of proposals or design ideas is sought rather than convergence on a solution which needs iterative refinement. Relatedly, our work accommodates varied participation in collective and collaborative settings. Different participants and design ideas can coexist, and in varied combinations, rather than a common and consistent set of commitments being adhered to. Ultimately, though, the relationship between our methods and others is something to explore in future work. What we hope we have done in previous work and here is show the viability and vitality of our 'alternatives'. The current paper has extended our ambition to offer a practice that knits together experimental making and performance with pedagogy in novel ways, and does this in a common spirit.

Our inquiry into rawness and roughness encourages the exploration of creative limitations, serves as a harbinger against overdesign, and allows a tolerance of intuitive, visceral, and naive responses. It also leads us to the 2023 NIME conference theme of 'frugality'. We must not overstate our accomplishments here. An inter-continental collaboration supported by air travel is not the most ascetic of activities. However, many of our makes were resource-non-intensive: using low power circuitry, preferring simple computation (remember: every operation expends energy), looking for possibilities that are already in (lightly pre-cooked) materials, or can be found in what has been discarded. A community of practice combining making, performance, and learning does not have to be a resource-indulgent one. It can be frugal and fruitful. After all, 'frugal' does have an etymological root in the Latin frux, meaning fruit.

8. ACKNOWLEDGMENTS

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9. ETHICAL STANDARDS

The funders of our work gave us full freedom to realise the research as we wished and exerted no undue influence. All participation in our events was voluntary and full briefings were given about any questions of safety arising in the work. Participants could withdraw at any moment. We have no conflicts of interest to report.

10. REFERENCES

1. K. Barad. 2007. Meeting the Universe Halfway. Duke.
2. J. Bowers. 2012. The logic of annotated portfolios. In Proc. DIS '12. ACM, New York, 68-77.
3. J. Bowers, P. Archer. 2005. Not Hyper, Not Meta, Not Cyber but Infra-Instruments. In Proc. NIME 2005.
4. T. Ingold. 2013. Making. Routledge.
5. J. Bowers, T. Shaw, S. Bowen. 2016. Many Makings: Entangling Publics, Participation and Things in a Complex Collaborative Context. In Proceedings of Designing Interactive Systems (DIS 2016), Brisbane, June 2016. New York: ACM. Pages 1246-1257.
6. J. Bowers, O. Green. 2018. All the Noises: Hijacking Listening Machines for Performative Research. In Proc. NIME 2018.
7. E. Wenger, R. McDermott, W. M. Snyder. 2002. Cultivating Communities of Practice. Boston: Harvard Business School Press.
8. A. Shaughnessy. Collaborate or Die: Graphic design as ensemble performance. Design Observer, 18 May 2016.
9. Giacomo Lepri, John Bowers, Samantha Topley, et al. 2022. The 10,000 Instruments Workshop - (Im)practical Research for Critical Speculation. Proceedings of the

International Conference on New Interfaces for Musical Expression. http://doi.org/10.21428/92fbeb44.9e7c9ba3

10. J. Lave, E. Wenger. 1991. Situated Learning: Legitimate Peripheral Participation. Cambridge: CUP.
11. C. Lévi-Strauss. 1994. The Raw and the Cooked: Introduction to a Science of Mythology. Pimlico, London.
12. E. Wenger, 1998. Communities of Practice: Learning, Meaning, and Identity. Cambridge: CUP.
13. J. Richards & T. Shaw. 2022. Against Augmentation. Ricercare, (15), 59–75.
14. J. Richards & T. Shaw. 2022. Improvisation through Performance-installation. Organised Sound, 1-12.
15. J. Richards, 2021. Sacrificial Floors and Tables: Making/Unmaking Sound. In Grant, J., Matthias, J. and Prior, D. (eds.) The Oxford Handbook of Sound Art. Oxford: Oxford University Press, 173–90
16. J. Richards and M. Wainwright. 2019. Microcomputer Music.
17. https://www.dirtyelectronics.org/docs/microcomputer_music.pdf
18. J. Richards. 2020. Against Stripboard? https://popupforcollaborativemusicmaking.wordpress.com/
19. J. Richards. 2021. Radical Nails. Code for the Radical Chip available at: https://www.dirtyelectronics.org/docs/radical_nails.zip
20. J. Zimmerman, E. Stolterman, J. Forlizzi. 2010. An analysis and critique of research through design: toward a formalization of a research approach. In DIS '10: Proceedings of the 8th ACM Conference on Designing Interactive Systems, 310-319.
21. A. Marquez-Borbon, J. P. Martinez-Avila. 2018. The Problem of DMI Adoption and Longevity: Envisioning a NIME Performance Pedagogy. In Proc NIME 2018.
22. J. Bowers, J. Richards, T. Shaw, et al. 2016. One Knob To Rule Them All: Reductionist Interfaces for Expansionist Research. In Proc NIME 2016.
23. F. Morreale, A. McPherson. 2017. Design for Longevity: Ongoing Use of Instruments from NIME 2010-14. In Proc NIME 2017.
24. W. Gaver. 2012. What should we expect from research through design? In Proceedings of the SIGCHI conference on human factors in computing systems, 937–946.
25. W. Gaver, P. Gall Krogh, A. Boucher, D. Chatting. 2022. Emergence as a Feature of Practice-based Design Research. In Designing Interactive Systems Conference (DIS '22). Association for Computing Machinery, New York, NY, USA, 517–526.
26. M. Lugones. 1994. Purity, impurity, and separation. Signs: Journal of Women in Culture and Society, 19(2), 458–479.
27. B. Gaver, J. Bowers. 2012. Annotated Portfolios. Interactions 19, 4 (July 2012), 40–49.
28. Jacques Rancière. 2010. Dissensus: On Politics and Aesthetics. Bloomsbury.
29. Jacques Rancière. 1991. The Ignorant Schoolmaster: Five Lessons in Intellectual Emancipation. Stanford University Press.
30. Stratos Kountouras and Ioannis Zannos. 2017. Gestus: Teaching Soundscape Composition and Performance with a Tangible Interface. Proceedings of the International Conference on New Interfaces for Musical Expression, Aalborg University Copenhagen, pp. 336–341. http://doi.org/10.5281/zenodo.1176274
31. Frédéric Bevilacqua, Fabrice Guédy, Norbert Schnell, Emmanuel Fléty, and Nicolas Leroy. 2007. Wireless Sensor Interface and Gesture-Follower for Music Pedagogy. Proceedings of the International Conference on New Interfaces for Musical Expression, pp. 124–129. http://doi.org/10.5281/zenodo.1177045
32. Kia Ng and Paolo Nesi. 2008. i-Maestro : Technology-Enhanced Learning and Teaching for Music. Proceedings of the International Conference on New Interfaces for Musical Expression, pp. 225–228. http://doi.org/10.5281/zenodo.1179605
33. Jordan Hochenbaum and Ajay Kapur. 2013. Toward The Future Practice Room: Empowering Musical Pedagogy through Hyperinstruments. Proceedings of the International Conference on New Interfaces for Musical Expression, Graduate School of Culture Technology, KAIST, pp. 307–312. http://doi.org/10.5281/zenodo.1178552
34. Ajay Kapur, Michael Darling, Jim Murphy, Jordan Hochenbaum, Dimitri Diakopoulos, and Trimpin Trimpin. 2011. The KarmetiK NotomotoN : A New Breed of Musical Robot for Teaching and Performance. Proceedings of the International Conference on New Interfaces for Musical Expression, pp. 228–231. http://doi.org/10.5281/zenodo.1178059
35. Emily Robertson and Enrico Bertelli. 2014. Conductive Music: Teaching Innovative Interface Design and Composition Techniques with Open-Source Hardware. Proceedings of the International Conference on New Interfaces for Musical Expression, Goldsmiths, University of London, pp. 517–520. http://doi.org/10.5281/zenodo.1178921
36. Abby Aresty and Rachel Gibson. 2021. Changing GEAR: The Girls Electronic Arts Retreat's Teaching Interfaces for Musical Expression. Proceedings of the International Conference on New Interfaces for Musical Expression. http://doi.org/10.21428/92fbeb44.25757aca
37. Sergi Jordà and Sebastian Mealla. 2014. A Methodological Framework for Teaching, Evaluating and Informing NIME Design with a Focus on Mapping and Expressiveness. Proceedings of the International Conference on New Interfaces for Musical Expression, Goldsmiths, University of London, pp. 233–238. http://doi.org/10.5281/zenodo.1178824
38. Jiffer Harriman. 2015. Pd Poems and Teaching Tools. Proceedings of the International Conference on New Interfaces for Musical Expression, Louisiana State University, pp. 331–334. http://doi.org/10.5281/zenodo.1179074
39. Jan C. Schacher. 2013. Hybrid Musicianship — Teaching Gestural Interaction with Traditional and Digital Instruments. Proceedings of the International Conference on New Interfaces for Musical Expression, Graduate School of Culture Technology, KAIST, pp. 55–60. http://doi.org/10.5281/zenodo.1178656
40. You Nakai. 2021. Reminded by the Instruments: David Tudor's Music. Oxford University Press.
41. Sethares, William; Milne, A.; Tiedje, S.; Prechtl, A.; Plamondon, J. 2009. "Spectral Tools for Dynamic Tonality

and Audio Morphing". Computer Music Journal. 33 (2): 71–84. doi:10.1162/comj.2009.33.2.71

42. J. Pressing. Nonlinear Maps as Generators of Musical Design. Computer Music Journal, vol. 12, no. 2, pp. 35-46, 1988.
43. N. Collins. 2020.. Twitching Loudspeakers. Chapter 5. Handmade Electronic Music. Third edition. Routledge.
44. John Bowers and Vanessa Yaremchuk. The Priority of the Component, or In Praise of Capricious Circuitry. Leonardo Music Journal 17: 39–40, 2007.
45. John Bowers. 2023. 'A Hapless But Entertaining Roar': Developing a Room Feedback System through Artistic Research and Aesthetic Reflection. To appear in Proceedings of the International Conference on New Interfaces for Musical Expression 2023.
46. J. Richards. 2022. Bad Buffer. Available at https://www.dirtyelectronics.org/docs/bad_buffer.pdf
47. T. Mudd. 2019. Material-Oriented Musical Interactions. In: Holland, S., Mudd, T., Wilkie-McKenna, K., McPherson, A., Wanderley, M. (eds) New Directions in Music and Human-Computer Interaction. Springer Series on Cultural Computing. Springer, Cham. https://doi.org/10.1007/978-3-319-92069-6_8
48. Enrique Tomás. 2020. A Playful Approach to Teaching NIME: Pedagogical Methods from a Practice-Based Perspective. Proceedings of the International Conference on New Interfaces for Musical Expression, Birmingham City University, pp. 143–148. http://doi.org/10.5281/zenodo.4813280
49. Manuel DeLanda. 2016. Assemblage Theory. Edinburgh University Press.
50. William C. Seitz. 1961. The Art of Assemblage. Exhibition Catalogue. October 4 - November 12, 1961, The Museum of Modern Art, New York.