John Chantler

No Such Array

Developing a material and practice for electronic music performance

Skriftlig reflektion inom självständigt, konstnärligt arbete

Till dokumentationen hör även följande inspelning:
No Such Array (för Röda Sten Konsthall)
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1 Introduction

“To compose is to build an instrument” — Helmut Lachenmann

Over the last two years I have been designing and building a set of battery powered hybrid synthesizer speaker objects that can be deployed in any location without the need for any additional infrastructure. Composing for and performing with the resulting system has become the focus of my artistic practice. This project brings together the different skills and interests I have developed over the last twenty years — composition, design, synthesis, politics, performance — to investigate new methods for performing and experiencing electronic music. The work takes the idea of the impossibility of an objective listener as its starting position and generates environments that give agency to the listener to create their own sonic experience of a given space. I am also wrestling with questions of power and how this practice might work through its entanglement in various power relations as a minor practice by introducing and opening up the conditions of possibility for other actions.

The speaker system’s inherent flexibility and portability affords considerable opportunities to engage in site-specific practice and interrogate the role and function of sound and the possibilities for sound based performance in public space. The actual system can be assembled and disassembled very quickly and in different configurations — all of which has the possibility to create radically novel situations for listening and audience interaction that no longer rely on the cultural conventions of the concert hall or other formally or culturally designated spaces for music. This text traces the initial actions I have undertaken towards understanding and acting on these possibilities and recognises that properly understanding the potential of this affordance will be a rich site for future development.

Whilst there exists a number of outliers, the common option for presenting electronic music is a table of gear through a P.A. system. The academic or institutionally supported apogee of this setting is the multi-channel high fidelity speaker arrays of wavefield synthesis, various 3D dome systems, or the more eclectic collection of speakers that make up a loudspeaker orchestra, such as the Acousmonium of the Groupe de Recherches Musicales (GRM). With all of these situations there are very spe-

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1 The acousmonium was devised by François Bayle in 1974. The GRM is now part of INA — l’Institut National de l’Audiovisuel (The National Audiovisual Institute). See: https://inagrm.com/en
specific, historically rooted sets of aesthetics where specific things are expected, suggested or allowed.

*No Such Array* — The title for this series of works initially came from a common error message printed by the Pure Data software when it cannot load a specified data set. At the same time, as a title, it also refers to speaker arrays common in large scale public address systems and multichannel sound reproduction systems. This work is *no such array*.

In compiling the text that follows, I spent a good deal of time at first writing about the technical aspects. It was a reminder that I am deeply obsessed with basic questions of infrastructure. I sometimes questioned whether I was procrastinating, pushing back against what feels like a riskier or at least more vulnerable discussion of the aesthetics and poetics of the project. But in fact, this investigation of infrastructure is intimately tied to these same questions of aesthetics and poetics and it is the work that makes the other work possible.

I made conscious decisions for the project to take a particular form, using open source tools and constructing the speakers myself. This has been motivated by both a desire to learn, but also to engage with, surface and extend the learning already done by others. This matters. How I have gone about *doing the work* constructs a particular reality that opens up a site for experience, where knowledge is produced and can be folded back into the ongoing action of *doing the work*.

This thesis traces the aesthetic roots of my undertaking in the work of others, including Okkyung Lee, Rie Nakajima, Tetsuya Umeda, Marginal Consort, Tony Conrad and Luc Ferrari. It also details my own experience creating work for the GRM’s Acousmonium, the series of decisions made in creating my own alternative speaker orchestra, and the practical process of situated learning\(^2\) that I have undertaken to develop a performance practice via three stagings: at Röda Sten Konsthall in Göteborg, within a pedestrian underpass running below the E4 national highway, and at Järvafältet Nature Reserve, north of Stockholm.

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\(^2\) Seymour Wright’s writing (2013) on the group learning activity of an ‘emergent-AMM’ in the 1960s has provided a useful lens through which to understand this.
2 Towards A Minor Practice

2.1 Power & Aesthetics

I consider my work on this project to extend from a particular political and ethical imperative that consciously situates my activity within a discursively produced field of ever-changing power relations. It is work that has both aesthetic outcomes and political implications and, as a minor practice acts productively upon, within and through these relations towards the creation of new possibilities for resistance.

My initial university studies were in politics with a particular interest in political theory, feminist and indigenous politics that I have maintained in the intervening years. Whilst politics has it’s obvious manifestations within institutions, governmental bodies and nation-states, power relations are also immanent in economic market relations, domestic relations and the production and consumption of culture — the doing of cultural activity (Foucault, 1990, p. 85). Where there is power, there is resistance. This can and must take a variety of forms:

there is no single locus of great Refusal, no soul of revolt, source of all rebellions, or pure law of the revolutionary. Instead there is a plurality of resistances, each of them a special case: resistances that are possible, necessary, improbable; others that are spontaneous, savage, solitary, concerted, rampant, or violent; still others that are quick to compromise, interested, or sacrificial; by definition, they can only exist in the strategic field of power relations. (Foucault 1990, p. 87)

To make music is to situate oneself in a complex set of inter-related activities, histories and sites of potential that extend from how we learn to do it (and continue to learn), the institutions that validate and credentialize this learning and other modes of development that exist outside this frame — what Stefano Harney and Fred Moten call The Undercommons (2013) — to the various and nefarious options for the music’s public presentation, whether in concert or as recordings. Before, through, between and after all of this, there is politics at work and everyone who engages in music and its making is working towards the re-inscription of extant power relations or negotiating new forms for these relations — often doing both at the same time. The aesthetics and politics of this engagement is invariably intertwined.

1 Bachelor of Arts (Government). University of Queensland, 1997—1999.
2. Towards A Minor Practice

2.2 The Minor

My first encounter with the concept of the minor was in Branden W. Joseph's book Beyond The Dream Syndicate (2008). Joseph's book is nominally about Tony Conrad, but rather than presenting Conrad as a great man of history as might have been done traditionally — influential inventor of structuralist film, inventor of drone music, etc. — Joseph demonstrates how Conrad and his work related as a minor figure with a complex, critical but also productive and creative relationship to other artists, institutional structures and the wider field of artistic, social and political activity that was taking place at the time.

I am similarly interested in creating an understanding of my own activity as inextricably linked to a number of other actors, organisations and institutions. In attempting to consider my work as a minor practice — what artist and theorist Simon O’Sullivan (2005) describes as oppositional, affirmative, always political and emergent — I enter into a productively antagonistic and ultimately creative relation to those things that I am critical of and attempt to make transparent how they function through my work. The idea is that through a minor practice one can open up the space for imagining other possibilities. Discrete or concrete answers are not required, but “a speculative pragmatism where the question of what if? creates the possibility to ask what else?” (Manning, 2016, pp. 201-2). Erin Manning is an artist working with dance and other media and a cultural theorist and political philosopher. In her nuanced and provocative work detailing the character and possibilities of the minor gesture, she explains that:

> The minor gesture is an operative cut that opens experience to its potential. This operation is affirmative to its core—it affirms the field in its transformation, and it affirms the way this transformation emboldens the in-act of experience in the making. Affirmation is the creative force of a reorientation in the event. (Manning, 2016, p. 201)

Whilst there is considerable overlap in how I understand and deploy these concepts, there are many nuances in, for example, Manning’s crucial work that point to other ways of understanding how to go about any process of resistance. Most notably, she draws on the experience of neurodiversity to challenge the prevalence of what she calls the “seemingly unshakable triad intentionality-volition-agency” (Manning, 2016, p. 112). I can recognise through this, that in much of my work I have been seeking the possibility to act as the self-sustaining individual. The privilege this position enjoys is based on an idea that world is already determined by a strong sense of how a body relates to the world. Manning calls for a need to start with an understanding of that relation and proposes that “autistic perception gives us a direct account of relation

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4 The idea of the minor originates in Deleuze and Guattari’s study of Kafka (Deleuze & Guattari, 1986).
in-forming, an account that challenges the notion that the world comes parsed” (Manning, 2016, p. 113).

Whilst the work I have undertaken has been in response to my relationships to institutional infrastructure, it is important to remember that what will sustain possibilities outside of that frame is not building a speaker system but the systems of mutual aid, support and care that make participation possible. How my work relates to this specifically is both beyond the scope of this initial period of artistic research and has been additionally impacted by the current pandemic where modes of co-performance with the audience has not been possible. This needs to become part of my working process going forward and I relate some additional thinking with regards to this in the final chapter of this text.
3 The Break

One goal with this project has been to develop a new way for me to perform — to break old habits and create and hone new techniques. Fundamental to this shift is the decision to step away from the chair and table of common electronic music performance practice.

The standard club concert setup has the performer stationed behind the primary PA system and listening to themselves via monitors (usually a pair of lesser quality and lower bandwidth speakers). This is in part based on the need to minimise acoustic feedback. Not sharing this constraint, at some point I decided that I wanted to experience the same sound as the audience and started positioning my table of gear in front of the speakers either amongst or at least much closer to the audience.

Obviously the table of gear remains as an anchor locking me to that location and also acts as both a barrier between myself and the audience and a way of fixing our spatial relationship in both the euclidian (how we are physically positioned) and social sense (how we relate, interact and constitute space socially). 5

Internationally renown cellist, improvisor and composer Okkyung Lee6 is someone who in performance can radically upset the expected spatial relationship between performer and audience, playing her cello whilst standing and dragging it into the audience in a way that rejects any possibility of passive spectatorship and forces the audience to renegotiate their expectations as to what it means to watch. 7

For Lee, this act of reconfiguring the concert space also begins with a desire to have a better experience of her own sound, but it is also a way to upset the expectations inscribed within classical performance practice generally and playing the cello more specifically. Her aim is to alter the relationship between performer and audience, creating a tension that expands the experience beyond the purely aural, one that requires the audience to negotiate their own involvement in the situation. For Lee (personal communication, March 2021), when it works best, the audience works together and with Lee in the creation of a collective experience.

Whilst I share these desires and aims with Lee, I think it is worth reflecting on how our practices are traditionally or commonly inscribed with different meanings and how these changes to the standardised arrangements and infrastructure can work to alter the way that power operates in context and the music’s sonic affect. As Lawrence English (2016) argues “Sonic affect, in psychological terms, is created through aes-

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5 That said, I appreciate that this barrier is also something that might usefully function as a refuge for other performers, and makes their work possible.

6 See: https://www.okkyunglee.info

7 For example: Radial System, Berlin, 5 July 2019; Borealis Festival for Experimental Music, Bergen, March 2017
thetic qualities: the timbre of the sound and how we receive it through our mesh of social and cultural understandings” (para. 8).

Following the work undertaken by artists Susanna Jablonski and Cara Tolmie as part of their *Gender of Sound* research project, it is possible to argue that our experience of sound and the performance practices that inscribe that experience are gendered. Playing cello is typically gendered as female, the cellist in turn subject to a male gaze. De rigueur *experimental* electronic music practice on the other hand can often be gendered as male. Whilst I think these are useful in many ways, Manning (2016) on the other hand, would argue against using such subject based identities:

> My proposal is that an approach that begins in the field of relation is precisely political because it does not begin with the agency of a preconceived group or solitary identity. Rather than beginning with subject-based identity, this approach begins in the ecology of practices where there is still room for new modes of existence to be invented. New modes of existence call forth an articulation of the political that is not reducible to preexisting constituencies, and thus is open to creating and celebrating modes of life-living as yet uncharted. (p. 123)

Both what Lee and I are doing upsets this gendering. For Lee, by refusing the possibility of passive spectacle and shifting responsibility. In my own work, the speaker system and related performance practice seeks to create a situation that invites the audience to devise their own experience inside and amongst the infrastructure — a situation of welcoming and care, rather than a structure dominated by barriers and high volume weaponised sound.

To stay with the trouble as per Donna Haraway (2016), it matters who is telling a particular story: “It matters which stories tell stories, which concepts think concepts. Mathematically, visually, narratively, it matters which figures figure figures, which systems systematize system” (Haraway, 2016, p. 101). For Lee it’s important to be able to reconfigure the situation as she does whereas I feel a responsibility to embrace the emasculating potential of removing and stepping away from the infrastructure that upholds the particular gendering of my history of practice and opening up the possibility for new modes of relating with and amongst an audience. Here there is both an ethical as well as a creative drive at work.

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3.1 What are we looking at?

It could be argued that electronic music has long had an awkward relationship to performance practice, and many artists have used different strategies to engender interest and novelty into the concert situation.

GRM director, composer and philosopher of the sonic François Bonnet argues that what is at stake is to "guide energies, to give them form, to make them become and resonate with that form and to be nourished, in return, by an energetic, differing, transformative diffraction" (Bonnet, 2019, p. 32).

Pierre Schaeffer’s idea of acousmatic listening (Schaeffer et al, 1952/2012) attempted to give primacy to the sonic object in and of itself. Writer and artist Seth Kim-Cohen (2009, pp. 12-13) disabuses this notion as involving "a naive, blank reception of the auditory" and a "[suspension] of semiotic activity in the listening experience."

Electronic performance practice remains dominated by the visual. The Acousmonium itself offers an extraordinary feast for the eyes — dozens of speakers of novel shapes and design that are staged and lit with dramatic flair.

Since the emergence of laptop based live performances there seemed to be a general acceptance that electronic music performances were boring. One strategy was to simply do as they were, but with the addition of projected videos, either done by the artists themselves or in collaboration with a film maker.

Sometimes the visual element might also have a direct relationship to the sound, from Russell Haswell’s live performances with synthesiser coupled to oscilloscope projection translating the rough and immediate sonics into a direct visual representation of their form to live-coding artists who go the other way: projecting the computer code they are running to create the sounds that are heard.

As I will show in more detail later in this text, there is some aspect of this direct relationship between sound and sight embedded within my system design, as one simultaneously sees and hears the speakers movement and the relationship between that movement and the sound. For example the swinging speaker’s movement could be mapped as a dampened low frequency sine wave and imagined as a control signal that is determining the rate and amount of phase and frequency displacement creating the Doppler effect that is heard.

The performance situation also creates both opportunities for me to reassert my physical presence or to more completely remove myself from the situation. What I might choose to do here will depend on context and the particular staging of the work in question, but this possible choreography is something new to explore. Critic-

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9 This problem rears its head again in the Covid-era of online concerts and the reassertion of visual primacy via the screen.

10 See for example: https://www.youtube.com/watch?v=-YTPR9fdnA4&t=4s
ally there are also more options for the audience to move which, following Manning (2016), opens up a myriad of possibilities:

What if we taught them that the ideal posture for learning or listening or “paying attention” was not standing still (or sitting still), but attuning to cues active in the field of relation? What if we directly allied the movement of thought to movement-moving? If we took the common event of cueing to movement-moving outlined above as the ground of experience, what else would we become capable of perceiving? What else could learning (and listening and attending) become? (p. 122)

3.2 Related performance practices

Compared to the tabletop mode of live performance, it is a very different feeling to perform by intuitively moving around the speakers around the space, slowly discovering different options for how to position and move things, that not only impact the sound, but also visual aesthetics. For example, the sculptural quality of making an impromptu stack of three different speakers or the dance-like motion of two hanging speakers spinning out of entanglement and falling apart from each other.

Ideas about spatialisation and multi-channel sound performance often extend out from the compartmentalisation of musical practice to genre. Within electronic music we are in general referencing the very specific histories and examples of spatial practice within that field, where the work of Xenakis and Le Corbusier on the Philips Pavilion at the 1958 World Fair in Brussels (Matossian, 2005) and Stockhausen’s 3D arrangement at the Osaka World Fair in 1970 are echoed in contemporary institutional realisations such as the Sound Dome of the ZKM Centre for Art and Media in Karlsruhe and the Birmingham ElectroAcoustic Sound Theatre (BEAST) at the University of Birmingham (Lynch & Savdoz, 2011). There are, of course, other histories of spatialised sound.

In thinking about how to approach my own performance within this project I’ve been especially taken by performances by Tetsuya Umeda11, Rie Nakajima12 and Marginal Consort13. All of these artists share an approach that entangles their physical

12 Rie Nakajima lives and works in London. For more information about her activities see: https://www.rienakajima.com
13 The current members of Marginal Consort are Kazuo Imai, Tomonao Koshikawa, Kei Shii and Masami Tada. Their traditionally annual concerts regularly took place at now defunct Tokyo venue SuperDeluxe who also published an excellent DVD and Book about the group on their inhouse Medama imprint. Marginal Consort performed in Stockholm as part of the Third Edition Festival for Other Music.
presence, the presence of any sounding objects and their movement, to the sonic experience of their performance. Umeda and Nakajima are not musicians in any traditional sense and their practice, whilst frequently centering sound, does not approach it through any recognisable musicianly lens. In their alteration of the dynamics of a performance space, Umeda and Nakajima also explicitly reconfigure the performer as listener. Marginal Consort on the other hand, create a situation where the audience needs to make explicit choices about how they take in the concert given its unusual physical arrangement. They too draw influence from outside music. The members first met as students of legendary Japanese experimentalist Kosugi Takehisa at Bigakko — an independent art school (Maude-Roxby & Giroux, 2014).

I also specify these three as their practice is still nominally electro-acoustic. Purely acoustic instruments afford different possibilities for approaching sound spatialisation and something like Anthony Braxton’s Spatial Genome Project (Akamu, 2019) brilliantly explores the possibilities that this affords, where “music becomes a property of the space and public spaces become the medium of the music. The division between stage and auditorium disappears” (Hoyer, 2019).

Umeda performs with both specific materials such as dry ice, heated cans filled with rice, and raw electricity, combining them with other objects found on site to produce what is usually a discrete sequence of sounds that are exquisite, surprising and choreographed with nonchalant grace as he moves around the space activating and steering his constructions.

Nakajima collects dozens of her small kinetic sculptures that variably click and ping in rhythmic motion. Gently, quietly, she starts each off, amassing a whirring mass of textural activity that can either be concentrated on a table top or dispersed throughout the room.

Marginal Consort have devised a very specific approach to group improvisation. Originally a quintet, but now with four surviving members, their rare performances see each artist set up in the far corners of the room, coupled to their own amplification in a way where it is usually very difficult for them to hear what the others are doing. The audience in turn must also decide how to take in this diffused field of activity — to choose to listen to one or maybe two performers at once is possible, but the arrangement thwarts the possibility of easily absorbing the totality. The typically three hour duration of their concerts gives one opportunity to devise their own way through for an experience that is shared with all in attendance as a uniquely personal experience of the same event. An exaggeration of what is commonly experienced in a live event making explicit the subjectivity of the experience.
3.3 Infrastructure as material

When we listen to music, we must refuse the idea that music happens only when the musician enters and picks up an instrument; music is also the anticipation of the performance and the noises of appreciation it generates and the speaking that happens through and around it, making it and loving it, being in it while listening. (Jack Halberstam in Harney & Moten, 2013, p. 9)

This quote from Halberstam is a beautiful articulation of the kind of collective energy that I’ve experienced as both artist, listener and organiser where we all become the music and make it possible. It has guided me in thinking through how to conceive of festival programming14 and continues to guide my own artistic practice and how it makes present the infrastructure — including the locations, technical facilities and social relations — we rely on in order to gather, anticipate and celebrate listening.

Kim-Cohen (2009) argues that “as a practice, music is positively obsessed with its media specificity. Only music includes, as part of its discursive vocabulary, a term for the foreign matter threatening always to infect it: ‘the extramusical’” (p. 39). I argue that, whilst otherwise considered extramusical, this infrastructure for music’s presentation, organisation and funding impacts its aesthetic (musical) outcomes. My project aims to make this clear in the work itself.

Like Kim Cohen, I would argue that this rejection of and resistance to the extramusical is carried out in order to uphold the relative value of particular aesthetics — namely the superiority and purity of notated music. Aligned with this, the classical concert situation also presupposes the possibility of an objective true listenership and whilst they address spatialising sound in different ways, both the 3D dome type systems (such as the Klangkupolen in KMH’s Lilla Salen) and the GRM’s Acousmonium are also optimised for an ideal listening position and remain attached to the possibility of an objective listener. I reject this as an impossibility and seek to maximise a plurality of experience(s) in encountering the work. To create the kind of experimental situation that Profanter et al (2019) describe where “the stakes for meaning are still fuzzy and not yet defined, the conditions for legibility become a responsibility shared between audience, artist, and organiser” (p. 8).

14 In 2016 I founded the Edition Festival for Other Music and continue to work as the festival’s Artistic Director.
3.4 GRM commission: Tomorrow is Too Late

*Tomorrow is Too Late* (Chantler, 2019) was a commission from the GRM for the *Présencés Électronique* festival in 2018. I worked at the GRM studio for two weeks split over a month long period leading up to the concert at the *Maison de la Radio* in Paris where I presented the piece using the Acousmonium — the GRMs unique system for multi-channel sound performance originally devised by François Bayle in the early 1970s.\(^{15}\)

The original invitation to work at the GRM was for me to use their recently completed recreation of the synthesizer devised and built for them by François Coupigny in the late 1960s. Many classic photos from the GRM archives show the system as it was embedded in a kind of mixing desk console. A smaller, more portable arrangement of modules had been in use in the years prior to in-house engineer Philip Dao’s reverse engineering project taking shape, but it had started to become unreliable — especially the dual layer pin matrix that was used to connect everything together and which has been forsaken in the new arrangement for 1/8” jack connections on each module and a derivation of the Buchla 200 series matrix mixer.\(^{16}\) This new GRM synth is housed in a large sloping case and at the time I first sat with it for this piece consisted of two banks of eight units of the two types of oscillator — a sine wave generator (no voltage control) and a universal oscillator (with sync and voltage control of frequency). These were supplemented by some basic attack-release envelope generators that could loop with a variable on/off time, voltage controlled amplifiers and ring modulators.

The studio also had a five panel *Serge Modular system*\(^{17}\) — something I was much more familiar with — so I decided to combine the two systems in order to achieve some level of the instrumental proficiency I needed to complete something in the tight timeframe.

\(^{15}\) See this short video about the Coupigny/GRM synth and my studio visit: [https://www.youtube.com/watch?v=JQng3gksZzY](https://www.youtube.com/watch?v=JQng3gksZzY)

\(^{16}\) See [https://modularsynthesis.com/roman/buchla205/205dmm.htm](https://modularsynthesis.com/roman/buchla205/205dmm.htm)

\(^{17}\) See: [http://www.serge-fans.com](http://www.serge-fans.com) for general information on the Serge Modular. The GRM system contains all custom panels, each with different purposes: sound generation, modulation, sound processing, mixing, a hybrid keyboard sequencer panel (the TKB) for control.
As much as part of the experience was about breathing in the air of such a storied place and wrestling with its aesthetic legacy, the commission was also a valuable opportunity to experience the kind of workflow involved in making a piece that is then presented on the Acousmonium. Nearly fifty years on, the process still mirrors what François Bayle (2019) describes in his foundational essay on the Acousmonium from 1975:

Indeed, generally speaking we might say that there is still no good solution to the problem very simply because composers, always and still today rather too pre-occupied with their creations, have tended to lavish all of their attention on the crafting of the work, which takes place in the situation of the studio—an artificial situation—rather than developing a professional approach to translating their musical intentions into public performance. Sometimes they merely assert these intentions at the highest intensity, “so that they remember it!” (p. 20)

I will certainly admit to being guilty, at least to some extent, of this last crime and in particular of being suckered by the ability to bring out high frequency details to the detriment of everyone’s long term cochlear health. Successfully translating a studio work into a performance via the Acousmonium takes practice and requires an embodied knowledge with many parallels to instrumental performance. The system affords possibilities of material, spectral and spatial transformation that can be radically revealing — what Bayle (2019) referred to as a “great opening up of the spectrum of signifying units, both in terms of the dimensions of these units (dynamic dimension, temporal dimension) and their quality (heterogeneity, complexity)” (p. 21). However, this affordance also means that the nuances of a piece can also be trampled by a clumsy application of those same possibilities.
This experience of performing with the Acousmonium in Paris and hearing other works performed has provided a vital point of reference for these affordances that loops back to inform the initial process of composition that I have undertaken since.

Working at the GRM and performing with the Acousmonium is, however, linked to a whole set of specific privileges that allow me access to that kind of space and to do that kind of work. At the same time I am very much attracted to the aesthetics of that system and the possibility it creates for a creative, variable transferral of energy in performance. Part of the No Such Array project includes an attempt to draw from my GRM experience by making something of my own that can make access issues explicit through the ways in which the work is presented. Something that doesn’t need the institutional support of a truck and half a dozen technicians is not going to be the same, but the response can still open up vital future possibilities for the guiding of energies. My decision to include spherical speaker enclosures is a direct nod to the classic spherical speakers included as part of the Acousmonium that are made by the French company Elipson. Mine are made DIY by clamping two medium size IKEA salad bowls together with a lasercut plywood plate glued to one of the bowls.¹⁸

I also hope that in its use of different types of speakers and their open, felt placement that it embodies a rejoinder to the aesthetics I have seen deployed in relation to 3D Dome systems. These either draw on ideas of precision and scientific research, go against Bayle’s directive to move beyond the assertion of composerly intentions by brute force sonic pressure or weaponise computer processing power for a multi-channel audio arms race where higher orders of ambisonics are waved around like a phallus.

¹⁸ When researching possibilities for speaker construction I stumbled upon a whole sub community of DIY speaker builders who had been repurposing these bowls for years. There is even a company selling a pair of what are clearly IKEA bowl speakers at 1000 euro a go!
4 Developing a Material

4.1 The appearance of simplicity

"Make no mistake, I only achieve simplicity with enormous effort" — Clarice Lispector

After years working with modular synthisers and performing with and through a messy explosion of spaghetti-like cabling I was interested to remove visible references to complexity from the objects outward appearance. In general, I wanted the technical functionality and interactive elements to be completely invisible. The final units only have a simple on/off switch visible.

The objects that I have built retain a simple, functional appearance. My aim here is to shift some of the attention away from some special or unusual quality of the objects themselves towards the sounds they are producing and how those sounds are shifting and changing in relation to the performance space. But there remains a tension as part of the very argument that I am making is that there is no possibility of neutrality without aesthetic implications. I want their visual appearance to reference typical concert loudspeakers and home hifi rather than for them to take on a status as art objects or be overly specific in their ascribed meanings. The beautiful, suspended, sounding objects that Sol Andersson has been making (Andersson, 2021) point towards other paths one could take when wrestling with similar questions of performance and infrastructure and the over-sized horns used by Marina Rosenfeld in her work Public Address at the Park Avenue Armory in New York have a different set of associations (sports grounds, transit stations) and ascribed meanings that she is very intentionally exploiting in that work. Rosenfeld’s speakers are so visually rich in and of themselves that it works as an installation, even without sound, as the horns have a resonant, or pregnant potential for a particular kind of (imagined) sounding that is embedded in our collective memory.

The speakers within my system on the other hand have much less referential potential. My aim and hope here is for allowing the possibility of greater focus on what they are actually doing in a space — their physical movements and the relationship of that to the sounds they emit — rather than on the histories they collect and represent in their deployment. The system has been designed to allow me to develop multiple works for performance with different configurations for radically different situations.

19 See Rosenfeld (2013) and Dietz (2013)

20 Christian Marclay is another artist who often exploits the sounding potential of objects and images without using any ‘actual’ sound.
Figure 2: Spherical speakers under construction at Stockholm Makerspace
4.2 To touch, to hold and to carry

Growing up, my parent's had a turntable and small cache of LPs. Of course, the needle would regularly break as a result of careless childhood interventions and I quickly learnt not to touch. One of my primary routes into electronic music was through hip hop and going to hear a local DJ seamlessly mix multiple records by directly handling the records, bumping tempos, scratching samples, etc. and I remember the liberating feeling when I first got turntables of my own, grabbed a record, pulled it back and scratched it. In my idea of what a record player was for this was absolutely forbidden and doing that meant you are not going to have a working record player for the next year.

I think there is a kindred feeling with these objects. One can directly touch the source of the sound — basic gestures of blocking the speaker with your hands for example makes for a radical change in timbre. But rather than a musical instrument culturally conditioned for a designated mode of interaction, they are, like the turntable, more readily associated with reproduction technology or performance infrastructure that is typically out of bounds or out of reach.

The objects needed to be light and small enough to be easily lifted and moved around and they should not require any special reinforcement when hung from ceiling supports or suspended from a tree branch. At the same time, each object needed to be big enough to house all of the electronics.21 My initial goal was to be able to transport the system for concerts using a maximum of two regular suitcases that could be checked as normal luggage on an aircraft if flying. This has been realised. For the second and third stagings detailed below it was even possible to walk to the sites, carrying all of the equipment.

4.3 Control, interaction, gestures, logic

Whilst in photographic documentation the speaker system can appear like an installation, it has been explicitly conceived of as a system for performance. It is meant to be activated, altered and played and I have developed a way to interact with it in order to achieve specific types of control and modes of performance.

I recall a tendency I had (and continue to work against) when performing in the traditional synthesiser-on-table arrangement where I would try to project a perform-

21 See Figure 8 on page 27. The latest version includes a stack of three 80mm x 60mm printed circuit boards that are 45mm high: Raspberry Pi 4b+, a hifiberry DAC+ for higher quality sound, and a custom interface circuit board. There is also a 100W mono t-amp amplifier 75mm x 55mm x 20mm. These are all powered by a single three cell lithium polymer (LiPo) battery (35mm x 35mm x 115mm). The tweeter speaker housing can be smaller due to the short depth of the driver, and the current design also uses a smaller battery, though this reduces operation time significantly (~2.5hrs instead of the 10+hrs possible with the larger battery).
ative, physical, gestural affect commensurate with the sonic affect I was generating: Gurning, exaggerated knob twisting. This project can be seen as a way of forcing myself outside of this, adding to a history of strategies for destabilising commonly held ideas about musical performance in order to achieve particular aesthetic goals (e.g. punk and hardcore). I can relate here to my own early exposure to this idea and my experience performing with the group 

Maher Shalal Hash Baz who’s visionary catalyst Tori Kudo has recruited amateur musicians since the early 1980s to create a music that would not at all be possible with players of recognisable skill.  

Continuing in the spirit of the break with my past approach to performance I wanted to shift the focus from achieving a kind of instrumental expression with the speakers and instead look towards other modes of interaction that might open up new possibilities for performance.

The Raspberry Pi is connected to a 3-axis accelerometer. Using a Python script, the data is sent to Pd where it is processed to provide triggers and other signals for basic control over the synthesizer patch. However, instead of, for example, directly coupling movement data to specific parameters — like oscillator frequency, filter cutoff or volume — I decided to focus on programming the accelerometer that controls each speaker to respond to a simple tapping gesture and to generate different logical states based on what the speakers are doing, for example, spinning, swinging, or switching sides. For example, a single or double tap to the speaker enclosure can be set to send a trigger that steps through a bank of presets; the gravitational force can be used to determine which side of the box speakers is in an upright position, sending a trigger signal to open the sound for up a sub-section of the patch; calculating changes in the amount of acceleration over time can be used to determine if a hanging speaker has stopped spinning or swinging and can instantiate a change to the music when this occurs.

Beyond this technologically mediated interface with the sound generating guts of the speaker, there remains the possibility to work with and modify the sound by altering the speakers physical relationship with the performance space. Setting suspended units to spin or swing, covering the speaker element or bringing it into close proximity to various surfaces, resonant bodies and other speakers in the system all offer different ways to bring the sounds alive and guide their energies in a process of attunement to the physical and social space of the performance.

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22 See Blues du Jour (2003) for a good example of this aesthetic. My own amateur performance practice, on computer, is included on Live Aoiheya January 2003 (2005)


24 See the appendices for copies of the three scripts that I have used
4.4 Choosing a sound generator

There are several options one could choose for generating sound in a system such as this. In my case, this whole project was preceded by my use of Automatonism\textsuperscript{25} — a digital modular synthesiser built within the open source software Pure Data (Pd), a "real-time graphical programming environment for audio, video, and graphical processing."\textsuperscript{26} that I was introduced to in 2017.\textsuperscript{27} Automatonism instantly felt familiar and I was able to quickly transfer my experience from the analog to digital domain and create sounds and music that I was excited by. I began incorporating a number of patches into my live performances.\textsuperscript{28} Two things were significant for me about Automatonism in the beginning:\textsuperscript{29} Firstly, I could bypass the steep learning curve that had always steered me away from Pd and its commercial cousin MAX/MSP. Secondly, Automatonism contains an excellent preset manager that made saving patch variations and then shifting between these variations incredibly simple.

Knowing that Pd could run on Linux and a Raspberry Pi got me thinking about possibilities for portable, standalone instruments and that combining Automatonism’s preset manager with the accelerometer’s inbuilt tap detection could make for sufficient variety in performance and bypass the need for any other types of controls (e.g. the potentiometers and cables of a modular synthesiser).

It is also important for me that this system is open source and freely available. This way I can also publish the work that I have done to extend the system and other people can also contribute to its development. There will always be a lot to learn with these kinds of tools and different ways of solving the same problems, but hopefully by publishing and sharing my work, access will become easier.

4.5 Synthesis, Frequency modulation and just intonation

I was first introduced to the idea of tuning based on rational numbers via Tony Conrad and his Early Minimalism project (Conrad, 1996) which seeks to reimagine a possible set of works from the early sixties concurrent to his involvement in the Theatre of Eternal Music alongside La Monte Young, Marian Zazeela, John Cale and Angus Maclise. The project was at least in part a response to La Monte Young’s refusal to release recordings from this period unless Conrad and Cale agreed to signing a docu-

\textsuperscript{25} See https://www.automatonism.com/the-software
\textsuperscript{26} See https://puredata.info/downloads/pure-data
\textsuperscript{27} Thanks to Sean Clancy for introducing me to Automatonism developer Johan Eriksson who was then completing his PhD under Sean’s tutelage at Birmingham Conservatoire in the UK.
\textsuperscript{28} This performance from 2020 relies heavily of several Automatonism patches. For most the preset manager is switched manually, but for others it is triggered and/or addressed by elements within each patch preset creating semi-chaotic recurring variations https://youtu.be/ObPYd4JqlA8?t=2123
\textsuperscript{29} I will discuss later in this text some of the shortfalls of the system and the modifications that I have made in order to achieve certain artistic goals.
ment acknowledging Young’s sole authorship of the music they had made as a group (Conrad, 1996). Unlike Young’s more ascetic approach to the use of rational numbers — since taken up with striking, gorgeous results by composers such as Ellen Arkbro (2017) and Kali Malone (2018). Given La Monte Young’s predilection for old school master-disciple relationships and the transferral rather than collective production of knowledge, just intonation can often feel like a cult. Conrad, on the other hand, treats the possibilities they provide with his characteristic irreverence and gives permission for wild experimentation free of any adherence to dogma.\(^{10}\)

Following this I started to build the majority of the harmonic relations within my music using the subharmonic series. The Serge analog synthesiser that I use includes a slope generator module that when triggered by another suitable signal, outputs a signal that is a whole number division of the source signal. The particular division is determined by the value of the rise and fall sections of the circuit (set manually or via voltage control). This is commonly used at control rates for pulse division, but when triggered by a high frequency signal, shifting the rise/fall times from fast to slow steps through the subharmonic series relative to the frequency of the source. Having worked out which combination of source signal and control worked best, I started using multiple instances of the slope generator module to generate chords that would be automatically in tune. Indicative examples from my published recordings include *Falling Forward* from *Which Way To Leave?* (2016); *Logic Being The Lowest Form of Magic, Pt III.* (2018); and *Doing Nothing, Nothing Doing* (2020).\(^{31}\) What I also realised was that not only were these fundamental tones now in tune, but that audio rate frequency modulation of the signals would also generate partials that were harmonically related, rather than the enharmonic bell tones generated when this technique is used with oscillators tuned in equal temperament.

### 4.5.1 Software implementation

Automatonism was designed for the equal temperament system of tuning that has acted as the basis for most of the commercial electronic music instruments that have been produced and to select the pitch of the oscillators it uses the standard range of 128 values used by the MIDI protocol, allowing for easy integration with keyboard controllers.

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\(^{10}\) Within this field I’m also very interested in contemporary composers who have studied under James Tenney and his work on mapping what he calls ‘harmonic space’. Notably Lamb (2019) and Sabat (2017).

\(^{31}\) This last piece was recorded shortly after Conrad’s death in 2016 as a homage. I tried to replicate his string attack in the swirling, phaser-heavy chords and the repeated lower tones are a reference to the long string instrument he made for his 1975 multimedia piece *Ten Years Alive on The Infinite Plain* (2017).
Developing a Material

When putting together patches for the speaker system this started to become a real limitation. I wanted to find a way of replicating the kind of tuning system that I had been using with the Serge and needed to work out how to integrate that within Automatonism’s convenient preset recall system.

Around this time I also read Kyle Gann’s book *The Arithmetic of Listening: Tuning Theory and History for the Impractical Musician* (2019) which made clear the theory behind different approaches to just intonation and how they might be practically implemented. Using his work as a basis, I set about modifying the *bandwidth limited oscillator* that is part of the Automatonism set of modules so that the oscillator’s frequency could be selected from a table of ratio values with a slider to choose a particular scale, another to select the scale degree, and then a third slider to shift the octave (either one, two or three octaves up or down). Both the scale degree and octave could be addressed by any of the control signals in the Automatonism system and different settings could be saved as a preset. The scale references a root frequency that is set globally for a patch.

![Figure 3: The original BWL-OSC on the left and two instances in modified form as a RATIO-OSC on the right, showing the selected scale, degree (ratio) and the output frequency (rounded to nearest integer).](image-url)
5 Developing a Practice

5.1 First Staging — *No Such Array (för Röda Sten Konsthall)*

I had been invited to perform at *Röda Sten Konsthall* in November 2020 as part of a small festival organised by the Göteborg new music presenting organisation *Levande Musik*. However, due to heightened Covid-19 restrictions on gatherings introduced a week prior, the public performance was cancelled. Luckily, I was still able to travel to Göteborg and work over a three day period in the space, making video and audio documentation of some audience-free performance activity.\(^\text{32}\)

*Röda Sten Konsthall* is situated within a former industrial building. My work happened within the main gallery on the second floor — a very large, open space with a ceiling height that varies from 9 to 11 metres — that commonly plays host to large scale site-specific art works. The general acoustic of the space is characterised by hard, reflective surfaces that create considerable reverberation and a persistent low hum generated by the suspension bridge that passes by the building.

\[\text{Figure 4: Performing at Röda Sten Konsthall, November 2020.}\]

\(^{32}\) This video documentation can be viewed at https://vimeo.com/498996861
5.1.1 Setup, material adjustment

For the music included in this staging, I aimed to keep things as simple as possible — sustained basic intervals of simple tones with infrequent changes initiated through performance — so that the individual, spatially distributed parts could readily form a coherent whole.

We decided to hang the speakers in a way that suggested no fixed line or specific primitive geometry (a ring, for example). Röda Sten’s house technician Calle Andersson suspended five 1mm wire lines from the light rigging and constructed a temporary joist within one of the grain silo openings for a sixth line. The four spherical speakers could then be easily moved between these or multiple hung together from a single line. The arrangement in the main section of the room roughly resembles the southern cross star constellation.

The speakers were mostly separated in the space, but it was still possible for two of the speakers to pass each other. The initial idea was to test how this might create interference or some other kind of sonic effect. While this didn’t amount to much, what it did allow was for the possibility that the two speakers could crash into each other if swung in a haphazard way — a beautiful moment of wires intertwined, spinning until the speakers touched, then slowly unravelling and falling apart.

One speaker was positioned close to one of the main support columns. The idea here being that when listening from the other side of the column, it would act as a baffle, replicating the hard stereo separation you get from speakers spinning within a Leslie cabinet. This effect worked, though subtly.

In addition to the spherical, hanging speakers, I also had four box-shaped units and a tweeter housed in a wooden tubular shell.

The reverberant acoustic meant that the volume of each individual speaker only needed to be modest in order for the sound to reflect off nearby surfaces and fill the space. Counter-intuitively, adding more speakers — at least with the same set of similar sounding patches — did not noticeably add to the richness or depth of the sound world and I feel that for this kind of hyper active acoustic environment it would have been better to have different sets of speaker pairs, where each pair shared similar sound sets, but had rather different material to the other pairs or complementary parts for a richer variety of spatial orchestration.

Thinking this might also just be symptomatic of the parts that were in play here being very drone-like with mostly sustained sounds I took the opportunity on the second day to modify the patches, introducing changes in amplitude. This made it possible to more clearly discern how different sounds were moving and morphing in space. At the same time it introduced other problems. The new rhythmic element in-

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13 See Figure 5 for a photograph of all of the speakers in use for this staging. Figure 13 shows the tweeter in more detail.
introduced by the changes in amplitude made the patches more identifiably repeating rather than sustaining — shifting the perception of time and also how the material from different speakers were interacting with each other. This could have been overcome by creating variations in the amplitude modulation, but this was not possible in the short time available on site.

5.1.2 Performance

The cancellation of the concert meant being mostly alone in the room, but also a shift in duration. The action of performance — no longer as tightly coupled to a specific period of time (a typical 40 minute concert) — became quite different to what I had been anticipating. Time opened up. There were no longer the discrete beginnings and endings and the ritualised gestures normally associated with and that I would have imagined as necessary for a concert performance. Instead, I moved through a loose combination of different gestures. Lifting a speaker to let it fall and start swinging in a particular direction where they would usually go on swinging at an ever reducing arc for a few minutes before coming to rest. Setting them to spin, a motion that would then effectively continue — in a process of acceleration, deceleration and changing direction — until I intervened again. These hanging speakers were tapped to change the patch they were playing. On occasion the spinning and swinging motion would create a false trigger, but not so often as to create a problem.

Figure 5: Performing at Röda Sten Konsthall. This image shows all of the speakers that were in use and an example of how they were brought together in different combinations.
Developing a Practice

The box speakers I carried around the space, either periodically playing them like an instrument (the speakers were programmed to be silent when held at a non-90 degree angle and ring out a different sound for each side when it pointed to the floor) or leaving them to sound in places that were points of particular reflection. For example, the corner of the gallery has a metal spiral staircase running from the floor below up to the ceiling of the gallery. A speaker positioned either within or pointing towards this structure could elicit resonances and specular reflections from the metal surfaces.

I also spontaneously built small structures by stacking the speakers. This was done in order to give some visual sense to the recombinant possibilities they already exhibited via their sounding.

To some extent it felt like the material I had prepared for the speakers was insufficiently varied, but perhaps this would be a lesser concern if a shorter duration and the unpredictable interactions of a public were both in play. That said, the fundamental approach to how this work would be performed still held and felt like a productive shift forward and away from previous modes of performance I simply moved around the space, approaching the speakers and their sounding as an activity of curious listening. Setting them into motion and shifting their spatial position and relation to each other with a basic desire to see what would happen, what experience might emerge from those actions and then respond again in turn.

5.1.3 Audience

In the absence of an audience, it was difficult to appreciate how they might take in the setting and choose to interact with it. I was reminded of the unpredictability of other people’s associations as I was setting up and my phone kept buzzing. It was one of three annual ritualised interstate rugby league tournaments over in Australia and my brothers and father have decided to use the family messenger group for commentary. I sent them a picture from the install and after the game is over they suggest I should paint the ball speakers red and white like a thing out of Pokémon — something I’d never seen before, but certainly no great leap for the imagination once I had.

After I’d got more speakers up and running I shuddered to think of someone making associations with mobiles representing the planets, but on the train back to Stockholm I re-read a transcription of Robert Ashley’s text for The Backyard (1977) and its plainspoken mysticism about impossible geometry and the solar system and felt OK about it.
They are the planets in this scheme of things.
Giordano Bruno’s shot.
The problem is the arc.
The changing angle of the shot.
It defies geometry.
The drawings of a geocentric solar system, when we meet them in the books, make us
avert our eyes.
Heresy is heresy.

5.1.4 Development
The work at Röda Sten made a few technical issues clear. Unfortunately switching the
speakers on was very unreliable. The computer seemed to boot fine and the Python
scripts taking data from the accelerometers loaded most of the time, but the Pd patch
loaded maybe only 1 in 5 times. I found an alternative possibility for loading the files
using a systemd service that will also attempt to load the patch again when it fails,
but ultimately decided that I needed to revise the Pd patch so that whatever errors are
causing the crash are removed. At this point I also revisited work done in the software
SuperCollider, but this had even more critical problems with glitching audio that
rendered it unusable.
Revisiting the Pd patch was also an opportunity to open up the possibilities for
what the Ratio Oscillator could do. The original modified oscillator formed the basis
for the patches used in the composition of No Such Array as it was presented at Röda
Sten Konsthall and made it possible to achieve some of my goals with regards to the
pitch relationships and how the frequency modulation could sound. But once working
with this setup, it also pointed towards further possible modifications that would
both make the composition process more immediately exploratory (mostly by pre-
patching common connections I had been making) and would also allow for more
opportunities to, after Tony Conrad, “do funny things” (Hubby et al, 2016).
The New Ratio Oscillator (see Figure 6) is still based on the BWL-OSC but now
holds four instances, each with amplitude modulation (a digital implementation of
what would be a Voltage Controlled Amplifier (VCA) in the analog domain), within the
one submodule. It includes switchable frequency modulation (FM) inputs from either
a signal elsewhere in the Automatonism system or the amplitude modulated output
of one of the other oscillators in the submodule. There is also the possibility to use

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14 The systemd service checks to see if a particular application or file is running and then executes a
process based on the status — in this case, attempting to run the file again if it isn’t already.
15 An earlier, simpler version of one of the SuperCollider patches is included in the appendices.
16 So named as a nod to the New Timbral Oscillator introduced by Serge in the late 1970s.
the oscillators own output in a feedback loop which creates unstable frequencies and sliding pitches at low FM indices and noise at higher indices. The submodule also includes a mixer to which signals can be sent either pre or post VCA. This takes care of most of the common patching that I was doing and was otherwise becoming quite repetitive. It also allows for much faster audition of FM combinations and modulation indices.

The first Ratio Oscillator set the scale degree or ratio in relation to the specified root frequency. In addition to this I wanted to make it possible to do a few other things with the frequency selection and created DIVISION and STACK modes for selecting the frequencies of OSC2 and OSC3. In DIVISION mode, it is possible to specify an integer division of the interval selected by OSC1 and then choose (and address via voltage control) the degrees of this division as the frequency for OSC2 and OSC3. In STACK mode, instead of the selected ratio being in relation to the root frequency (OSC0), the ratio is calculated in relation to the frequency of the preceding oscillator — OSC1 for OSC2 and OSC2 for OSC3. These modes and this process draws on the experimental and pedagogical undertaking by anonymous Twitter user @mannfishh🎉

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https://twitter.com/mannfishh
who has taken the calendar date as an interval and subjected it to various processes of division and stacking to create a series of sometimes ridiculous, but frequently beautiful etudes. Tony Conrad also brought a great deal of humour into his own piece exploring non-octave interval divisions with his work for string quartet *Dividing The Fifth* (2008) which subjects a traditional melody to a radical détournement as he substitutes different divisions with each repetition of the theme, constantly upending our expectations of what is to come.

Finally, the NEW RATIO OSC includes a variable low pass filter to slew the incoming control signal and allow for glissando between the addressed scale degrees. Using the morph function within the preset manager it is also possible to create linear glissandi of up to 60 seconds in duration between the different fundamental frequency values assigned to different presets.

Another technical problem that had been present from the outset of the project was that the amplifier was picking up computer system noise — possibly due to some kind of grounding problems. At Röda Sten, the low amplifier volume combined with
the general environmental noise of the space meant that the system noise was hardly noticeable. However, given that it is very present when working in a studio setting and likely to create further problems in future, I designed and manufactured a printed circuit board (see Figure 7) that could be attached to the Raspberry Pi and that routes the audio through a small transformer (Lundahl LL1532\(^{38}\)) that effectively isolates the audio signal from the system noise.\(^{39}\) These are expensive (~500 Swedish Kronor each), but smaller, lighter and without the charging and maintenance requirements of running a second battery which might have been another possible solution. This board also contains improved connections for the accelerometer, battery and 5 volt regulator. Figure 8 shows the final configuration of the internal electronics and more detailed information, including schematics, is provided in the appendices.

\[\text{Figure 8: The revised guts of the speaker system}\]


\(^{39}\) Thanks to Daniel Araya, technician at the Elektronmusikstudion (EMS) in Stockholm for the loan of an old transformer Lundahl made for the Swedish Radio to test and verify that this would solve the problem.
5.2 Second Staging — E4-E4

This piece was a short study to assess the potential of smaller arrangements of the system and used only two speakers. These were installed in the pedestrian tunnel that passes under the E4 highway along the route between Häggvik Station and the eastern entrance to Järvafältet Nature Reserve.

The original plan was for the two speakers to spin whilst sounding simple sine waves at integer intervals of one of the lower room modes of the passageway so that waves of sound would pulse as they are projected between the short sides and then reduce in volume as they move away and project out along the length of the tunnel. The pattern of this pulsing would then shift as the frequency at which the speaker spins reduces until it switches direction and then speeds up again in a repeating cycle. The second speaker would do the same thing, but inevitable variations in the rate of change between the two speakers would lead to a process of continual variation as the two sound sources interact in different ways.

The piece was originally envisioned as something that could be staged ahead of the outdoor performance of *No Such Array (för Järvafältet)* and one aim for it was to amplify the sonic impact of architectural enclosure before audiences experienced similar material in the open, forest setting. Inevitably, the tunnel has multiple frequencies of increased resonant potential and I felt that I did not need to reduce the piece to a simple set of sine waves only in order to make the acoustic effects obvious. The musical material should also be able to stand on its own. By increasing the complexity of the sounding material — including sections of glissando, various time domain effects and sections of noise, I could also activate a broader set of resonant peaks and phantom sound images within the setting.

The music for this piece consists of 16 different frequency combinations set for the four signal generators within the *new ratio oscillator* (as described on p23). For the second of the two speakers, the fundamental frequency for each combination is doubled and thereby shifted up an octave. Each combination also includes variations in the source and depth of frequency modulation of each signal generator and different settings for the time domain effects that are mixed in with the final output. The system is set up to step through these 16 presets at time intervals of between 60-90 seconds. The actual switching between presets is a linear interpolation over a 30 second period between the values saved for each preset. As part of this *morphing*, the timbre of each oscillator output can change as FM depth is increased or decreased, any changes in the specified scale degree for oscillators two through four are stepped.

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40 Tom Erbe’s Soundhack +bubbler, +delay and +pitchdelay Pd externals that I hooked up to the *Automatonism* state-saving mechanism. Crucially, these run on both Linux and Mac OSX platforms.
and in the few instances where there are changes to the fundamental frequency\textsuperscript{41} this creates a perfect, linear glissando between the two pitches, smoothly shifting the frequency of the scale degrees at the same time. The sound also runs through two different delays, so elements of the prior preset continue to sound over the chord that follows, building up harmonically rich layers of sounding material for further complication by the acoustics of the tunnel which adds multiple resonances — especially in the lower frequencies — and comb filtering effects. Similar to the situation at Röda Sten, it felt necessary to reduce the amplifier level as the acoustic was giving back so much energy from what the speakers put out.

The spectrogram shown in \textit{Fig. 9}, generated by Adobe Audition, displays the frequency spectrum of a section of the audio for this piece as recorded directly from Pure Data. It clearly shows the discrete frequencies of the chords. The transitions between presets are marked A, B, and C and you can see how the frequencies overlap between presets. You also get a visual representation of some of the time domain effects that appear as noisier vertical columns in contrast to the otherwise more discrete frequencies of the New Ratio Oscillator.

\textit{Figure 9: E4-E4 Spectrogram}

Listening inside the tunnel, the speakers overpower most of the identifiable external noise and the sounds quickly take on the claustrophobic qualities of the tunnel’s architecture. This is further exacerbated by having experienced the awkwardness of an apparently confused general public trying to use the tunnel as simple passage at the same time.

\textsuperscript{41} The number box labelled ROOT_FREQ — See Figure 6.
By contrast, the same programme of material sounds as something rather beautiful in the studio environment or when the same speakers are placed outside in the open or even when heard from the opening of the tunnel installation where the sounds are mixed with the sound of passing traffic and birds.

5.2.1 Performance & Audience

For this piece the idea of performance takes on a different meaning. Conceived to take place outside and away from a designated space for culture (such as Röda Sten), it is, in its very essence, less about my ongoing interaction with the speakers in the space and shifting the relationship between audience and performer within that context and more about the act itself of installing them in such an unauthorised situation. This is where and how the core of the performance takes place and any other actions and gestures in this first iteration are only incidental to that.

Inevitably in such a public context one still engages an audience, but this time one of occasionally curious, though mostly agnostic or unwilling participants in the project. No one was openly hostile to our presence, but this is a possibility that needs to be imagined and thought through in future, rapid interventions into public space of this type and the knowledge from each staging or iteration needs to be feedback into how the next staging takes place. Given the potential a priori lack of consent, the sonic affect is potentially brutal regardless of its specific makeup. How to relate to the audience here is as much a site for experimentation as the sounds themselves and will likely have a greater impact on how the sounds are heard and experienced than any tweaking of the FM index.

5.2.2 Infrastructure

Given that so much of the focus of the work I have been undertaking is about infrastructure it is unsurprising that in shifting away from the classic infrastructure of the concert hall, you very quickly come up against other problems.

For this piece, the idea was to suspend the speakers from the ceiling of the tunnel, but I’d underestimated the dimensions and logistical difficulties of suspending something across a 3,5 metre expanse between two walls — especially one where any drilling activity would prompt a visit from the highway authorities. After entertaining a variety of potentially expensive or volatile solutions, the work for this piece was undertaken using two microphone stands to create a frame from which a speaker could hang (see Figure 10). The primary public outcome for this work is a stereo audio recording\(^\text{42}\), so there was less need to fuss over its visual appearance for an in-person audience. I will continue to investigate other possible solutions to this kind of problem that could be more tightly integrated into the setting’s structure and aesthetics.

\(^\text{42}\) Commissioned by Iklectik Art Lab, London, UK and due for publication in 2021
Figure 10: Running tests for E4-E4 with Henrik Frisk and Eli, the dog.
However, using this microphone stand arrangement did make it possible to mount and unmount the speakers in only a few minutes. The stands and speakers could also be readily transported by a single person on foot. The agility of this assemblage and the powerful way it was transformed by and in turn transformed the space points towards the radical potential for a variety of future unauthorised actions with different sub-assemblies of the larger collection of instruments.

Doing this kind of work bypasses the institutional or organisational requirements for presenting music, but, as per my earlier discussion of Foucault in 2.1 Power & Aesthetics, one remains entangled in relations of power and it is necessary to ask questions about how these make this action — installing the speakers alongside another middle aged white man and a little dog — possible for me in ways that would not be as readily available to others. At the same time, I hope that as a minor practice, it also opens up the field for what might be considered possible for others. This question and others that will follow emerge from the process of doing the work and it will be necessary to develop strategies for folding what emerges from each staging into future iterations so that these questions can be specifically addressed and approached in different ways.
5.3 Third Staging — *No Such Array (för Järvafältet)*

Järvafältet is a nature reserve to the north of Stockholm that stretches over an area of approximately 1700 hectares. It was a military training area between 1907 and 1970 after which time it was converted to a nature reserve. The eastern side of the reserve is only a short walk from where I live and I have been a regular visitor to the forest there since I first started coming to Sweden in 2005.

This work was staged in the section of forest that lies between the eastern edge of the reserve and the Southern end of lake Ravalen (see Figure 11). The forest in this area is mostly pine and birch with a mossy ground cover and is home to a great variety of birds, insects and other wildlife.

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43 I recall coming across a sign on one walk that said 'Varning för ...' with the bottom part of the sign having been removed by an apparent explosion.

44 For more on the area’s history see: https://stockholmskallan.stockholm.se/teman/stockholmsplatser/jarvafaltet/

45 Järvafältets Ornitoligiska Klubb (JOK) reports 173 different species sighted in the northern part of Järvafältet in 2020.

46 On an early evening stroll many years ago, I saw a group of deer running through the forest. At one point, one of the deer broke away from the group and leapt into the lake, swimming across as the sun set.
“Nature has never been benign, nor has the human.” (Kanngeiser 2021)

No Such Array (för Järvafältet) was also explicitly a reversal of a common mode within ambient music of adding field recordings to soft chords. Where the idea there is to add some naturalistic authenticity to computer generated lushness, my intention is to use computer generated sound to bring attention to the rich, weirdness of a specific location and to open up a space for listening to that location in new ways.

The idea of situating the work within Järvafältet was not driven by any desire to *return to nature*, but was a potential way of working through the ideas of *refusal as return* and *attunement* presented by sound artist and geographer AM Kanngeiser (2021) that seek to reassert an awareness of our entanglement with our surroundings and how the idea of nature has long been a discursive construction policed for political and economic goals. My work is against the ecofascist trope that *nature is healing* or some otherwise benign force otherwise disentangled from human activity (Kanngeiser, 2020). I hoped to begin working through these ideas in practice — through a process of attunement — to stop and listen, and try to understand how complicit my actions are in propagating particular ideas and how I can investigate and illuminate these problems in performance. As Kanngeiser (2021) argues: “To tune into does not stand in for something else; attunement is a starting point held in the suspension of what we think we know. A pause does not mean conciliation; it is a pause that might intervene in the rush to action or conclusion” (para. 13).

5.3.1 The Perimeter

For this staging, I hung four of the spherical speakers from tree branches positioned between approximately one hundred and fifty and three hundred metres apart from each other and fifty metres from the primary designated walking paths. These then formed a perimeter within which other activity took place. Inside this perimeter I placed three other speakers: on the ground, nestled within tree branches; and in a crevice created by a fallen tree. See Figure 12.
The hanging speakers sounded material similar to that used for the two speakers in E₄-E₄: held chords in just intonation with periodic changes. However, instead of continually sounding, the speakers were programmed for occasional periods of silence. Each speaker has a unique variation on the chords and there was no synchronisation between the four speakers, so this happened at different times with some moments where the speakers would sound on and off together.

With only a relatively short string to hang the speakers — instead of the long wire cable used at Röda Sten — the speakers only spin for a short time before coming to rest. In addition to this technical limitation, it also felt more appropriate for the location that there wasn’t such an identifiable spinning motion, but a more gentle and slow moving change of direction that mimicked the unpredictable onset and recession of wind and other identifiable sonic activity within the forest setting.

In general the volume of these hanging speakers was kept low so that the music could get lost in the forest or take on the quality of an apparition. Depending on the listener’s position and the direction the speakers were facing it would not be possible
Developing a Practice

to hear all of them at once and with the speakers only sounding intermittently, the audience is encouraged to question what it is they are hearing or if they are hearing any music at all. Here, composer Jakob Ullmann’s idea of *Disappearing Musics* is an inspiration. He is using low volume as part of an aesthetic quest to hear better whilst at the same time the low volume also functions as an ethical response to a specific situation (Cain, 2013).

5.3.2 Inside the perimeter

This idea of blurring the distinction between the extant sound of the forest and the music being performed is furthered by the speakers positioned within the perimeter. The material for these instruments consists solely of synthesis that seeks to imitate the kinds of sounds already present: an extraordinary variety of different bird calls, insect clicks, and the creaking of trees as they sway in the wind or a fallen tree rubs against a neighbour that is holding it upright.

The work of composer Luc Ferrari provides a useful reference point for some of the ideas that I am trying to work through with this practice. Even as a member of the GRM, Ferrari rejected the core idea of its co-founder Pierre Schaefer — that sounds could be detached from their source (Kim-Cohen, 2019, p. 177). Ferrari’s work engages with the very possibility of a sound’s meaning and what and for who it communicates. But is also shot through with irreverence and recognition that this meaning can be made in the process of composition. It is also “leavened with a mischievous sense of humor” (Kim-Cohen, 2019, p. 180) and I too hope that what might be funny about inserting a bunch of fake *nature* into the forest is not lost in the serious discussion of how this might affect how we listen to the other sounds at that site. This is also something Ferrari added after the fact to his night time recordings of a forest setting on *Presque Rien n°2, Ainsi continue la nuit dans ma tête multiple*.

If *Presque Rien n°1* is notable for its radical attitude which consists in creating a “composition” without any musical sound, *Presque Rien n°2, Ainsi continue la nuit dans ma tête multiple* contains elements that resemble music but immerse the listener in a dreamlike world. These elements signal the anecdotal transition from realism to fiction, or the moment when the real nighttime sounds are perceived inside the composer’s head. (Caux, 2012, p. 154)

The synthesised sounds in *No Such Array (för Järvafältet)* were created from a general impression — obtained by observation on site over a period of several weeks — of the broad types of sounds that are present rather than, for example, the direct resynthesis of a specific bird call. The sounds on two of the speakers are comprised of various series of clicks. These clicks are presented in different rhythmic combinations, with or without specifically pitched resonance and subject to different degrees and rates of frequency modulation and distortion.
The third speaker — a tweeter — sounds a patch that more closely resembles bird calls. Frequency modulation, a resonant filter and granular synthesis are used to generate a combination of sliding tones, chirps and clicks.

5.3.3 Audio Examples from No Such Array (för Järvafältet)

The following audio files show examples of the direct sound from Pd and provide a useful contrast to hearing the same or similar sounds on site.

Inside the Perimeter #1
Direct recording of synthesis from Pd:

Inside the Perimeter #2
Direct recording of synthesis from Pd:

Inside the Perimeter #3
Direct recording of synthesis from Pd:

Inside the Perimeter Combined
stereo mix of the above files:

Perimeter
stereo mix of direct recording of synthesis from Pd for the four different speakers:

As shown in Figure 13. The bad jokes never end. The name given to a speaker driver used for high frequency sound reproduction is indeed named after the higher frequency sound call of small birds, compared to the lower pitched ‘woof’ of a dog that gives it’s lower frequency partner — the woofer — its name.
Figure 13: Tweeter on site at Järvafältet Nature Reserve, February 2021.
5.3.4 Performance

As with *E4-E4*, the primary performative action for this piece involves its installation within a public setting. However, it also differs in significant ways. Firstly, the additional speakers and larger spacing create opportunities for me to adjust the speakers and how they are sounding in real-time — altering volume and using the tap detection function of the box speakers to alter what material is in play. But more crucially, it is something the audience is both invited to or has the possibility to discover. Given the larger area over which the performance takes place, there is both more opportunity for and an onus on the audience to actively engage with the site and make their own experience of the piece by physically repositioning themselves and also by engaging with and critically interrogating how they listen.

We can’t physically shut sounds out, but there is a psychological process at play where we choose — whether consciously or subconsciously — to hear what is going on around us and to process that information in different ways. This is a cultural process. As Seth Kim-Cohen states “The ear never closes” (Kim-Cohen, 2009, p. xviii). He uses this notion to argue against considering sound only as itself, a *singularity* or *instantaneity* (the blink of an eye), and argues for a need to connect sonic practices “to broader textual, conceptual, social, and political concerns” (2009, p. xix). We block out traffic noise in order to focus on a conversation, or where the illegibility of the same conversation draws our attention to noises that are making it hard to hear. We experience the same sounds differently based on our experience. This work attempts to set up a situation that makes strange the everyday practice of forest walking — to change the future experience of listening for those that experience the work. At the same time it is also set up in a situation which allows for other possibilities and the development of new practice, process and rituals for how musical material can be encountered that blurs the limits inscribed into definitions of a concert, installation or performance. Undertaking this performance has reinforced the necessity of engaging in *how* the audience comes to experience the music as it part of the music making process as the supposed neutrality of the location and infrastructure disappears and the ways of coming upon and being within the music become explicit dimensions of the material and performance.
6 Way Forward

The three different stagings that I have undertaken with No Such Array to date all point to a myriad of possible avenues for further exploration that will take a lifetime to exhaust. For now, I feel the way forward for my artistic research is to focus on trying to understand the overlapping themes that have emerged from the work I have undertaken to date: site-specificity, for and with others, documentation and transformation.

6.1 Site-Specificity

What is the relationship of sound to space within my work and how does that alter the logic and poetics of performance? This question can be approached on two fronts. To initiate an ongoing process of engagement and attunement with the site itself, both alone and with others, developing new material and altering existing material, in and outside performance, recognising that the project — as it exists now — is in a formative stage of its potential development. Secondly, by bringing the material as developed för Järvafältet and staging it on other sites, testing to see how it changes, what is permeable in the material and to what extent such permeability is desirable.

However, Miwon Kwon’s genealogy of site-specific practices within fine art remind us of the competing, overlapping definitions of what constitutes site-specificity and how the three paradigms she identifies — phenomenological, social/institutional and discursive — can all overlap in an artistic practice (Kwon, 2004). Site specificity doesn’t need to refer to the material site, but can also be the discursive site — where our understanding of the material location and our relationship to it is formulated. In this sense, where the work takes place — Järvafältet — doesn’t need to be the site of specificity, but rather provides material and inspiration. The site-specificity of the work resides in how this inscribes or illuminates discourses on listening, performance and infrastructure.

Either way, it is being in the minor practice of doing the artistic work that will generate the necessary knowledge and understanding of how site-specificity is manifest and operates within this project and can contribute to understanding its potential for electronic music performance.

6.2 For and With Others

The global pandemic has made engaging with different audiences and developing aligned methods for how this project can be for and with others much more difficult and sometimes practically impossible. However, even the experience of sharing this work with one other person at a time — for example, during site visits with teachers
and colleagues—has highlighted the transformative potential of the collective experience of listening. As this project seeks to invite new ways for this to happen, there is much to learn through the introduction, development and embodied experience of the extra-musical rituals, Halberstam’s anticipation and appreciation and the discourse(s) generated through the act of listening. As a collective experience, I expect this to shift, multiply and spin off in directions I have yet to anticipate, but in being there, in the listening with others, there are many new things to learn, and processes to invent that open up the possibility for asking Manning’s questions of What If? then What else?

6.3 Documentation

In Records Ruin The Landscape (2014), David Grubbs traces the ways in which recorded media has changed our understanding of historical performances involving sound—in ways that are limiting, distorting, but also revealing. With this in mind, I am interested to understand how I might think through different possibilities for documenting the work that I am doing. It thrives on the plurality of ways in which it can be experienced and it feels important to resist reducing it’s documentation to a stereo recording. At the same time it feels possible to explore the transformative and productive potential of the documentary act and event, opening it up to allow for and interrogate what happens in it and for new work to be made in the process.

6.4 Transformation

One nascent idea, draws inspiration from American artist Maryanne Amacher’s series of City Links where she installed a telephone line in a specific location (e.g. Boston Harbour) and used it broadcast the captured sound(s) back to her studio (at MIT) or to a performance location (Cimini & Dietz, 2021). I could use readily available HTML 5 capabilities to enable audiences to, via smartphone, record and broadcast their experience of listening to both a server for archiving but also a secondary location in realtime such as a more formally designated concert/performance space.

I would be interested to understand how this ‘amplified listening’ changes how the audience navigates and interacts with the work in turn initiating or developing their own performance. There are also a few other things I like about this, too. That the documentation is potentially another work that amplifies the impossibility of documenting the original work; and that there is also some potential, through this process, to democratise access to a more formally designated concert space, anticipating

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48 Thanks to Elsbeth Bergh, Christian Pallin, Åsa Stjerna, Henrik Frisk and Carina Thorén for taking the time to visit and discuss this work on site.
that this very process could also be hi-jacked with *unanticipated* modes of participation.

Fundamentally though, it is in many ways an extension of the second way forward in that it seeks to solve the problem of documentation (or realise the potential of the documentary act) through engagement with the audience, bringing their experience into the process and embedding it within the way the work lives on beyond the specific site of its initial occurrence. This will also require the development of knowledge establishing new modes of care and methods for inviting an audience into such an undertaking.
7 Reference List


8 Appendices

Documentation

8.0.1 No Such Array (för Röda Sten Konsthall)

Video recording, Stereo Sound:
john_chantler_no_such_array_roda_sten.mov

Software

8.0.2 Pd patches

Each folder linked below contains a modified version of Automatonism including accelerometer outputs (tap, static, sides), the Ratio Oscillator and all of the other files required to run the patch. Instantiate the patch by running the main.pd file in Pure Data.

![Figure 14: Detail from a Pd subpatch for bringing in and processing accelerometer data via the [netreceive] object](image)

The Pd patches rely on two Python scripts to send the accelerometer data and tap detection to Pd via the [Netreceive] object as seen in Figure 13. These Python scripts are initiated as background processes as part of the Raspberry Pi startup routine. The Python scripts are in turn dependent on the installation of all necessary libraries and dependencies for the accelerometer being used. I used an LIS3DH based accelero-
meter and following the online guides published by Adafruit (Adafruit, 2018) for installing circuit python and connecting the accelerometer to the Pi via the I2C protocol.

8.0.3 Tap Detection Python Script for Pd

Sends a 1 when tapped and a zero otherwise. The values in parenthesis that follow lis3dh.set_tap determine whether it is detected a single or double tap and the level of sensitivity.

Single tap, very sensitive

```
lis3dh.set_tap(1, 125)
```

Double tap, moderate sensitivity

```
lis3dh.set_tap(2, 70)
```
import os
import time
import board
import digitalio
import busio
import adafruit_lis3dh
from pythonosc import udp_client

# Hardware I2C setup. Use the CircuitPlayground built-in accelerometer if available;
# otherwise check I2C pins.
if hasattr(board, 'ACCELEROMETER_SCL'):
    i2c = busio.I2C(board.ACCELEROMETER_SCL, board.ACCELEROMETER_SDA)
    int1 = digitalio.DigitalInOut(board.ACCELEROMETER_INTERRUPT)
    lis3dh = adafruit_lis3dh.LIS3DH_I2C(i2c, address=0x19, int1=int1)
else:
    i2c = busio.I2C(board.SCL, board.SDA)  # Set to correct pin for interrupt!
    int1 = digitalio.DigitalInOut(board.D6)  # Set to correct pin for interrupt!
    lis3dh = adafruit_lis3dh.LIS3DH_I2C(i2c, int1=int1)

lis3dh.range = adafruit_lis3dh.RANGE_2_G

while True:
    # Read accelerometer values (in m / s ^ 2). Returns a 3-tuple of x, y, # z axis values. Divide them by 9.806 to convert to Gs.
    x, y, z = [value / adafruit_lis3dh.STANDARD_GRAVITY for value in
               lis3dh.acceleration]
    xG = "%.3f" % (x)
    yG = "%.3f" % (y)
    zG = "%.3f" % (z)

    print("x = %.3f G, y = %.3f G, z = %.3f G" % (x, y, z))
    # Small delay to keep things responsive but give time for interrupt process$    time.sleep(0.1)

    def send2Pd(message=''):    
        os.system("echo '\"' + message + '\"' | pdsend 3000")

    def xAxis():
        message = '1 ' + str(xG) + ';
        send2Pd(message)
        xAxis()

    def yAxis():
        message = '2 ' + str(yG) + ';
        send2Pd(message)
        yAxis()

    def zAxis():
        message = '3 ' + str(zG) + ';
        send2Pd(message)
        zAxis()

8.0.5 No Such Array (for Röda Sten Konsthall)

This archive folder contains the three Pd patches used in the performance of No Such Array (för Röda Sten Konsthall). Note that each patch will impact other patches if running in the same instance of Pd.


Box Speakers: 20.10.24-BB1
Spherical Speakers: 20.11.9_SWITCHING_2
8.0.6 No Such Array (för Järvafältet)

These folders contain the New Ratio Oscillator and the Perimeter and Inside Perimeter patches that form the basis of this work. It requires the additional installation of the Cyclone and Soundhack externals to function fully. Note that each patch will impact other patches if running in the same instance of Pd.


8.0.7 SuperCollider Example

This patch, written in an alternative open source sound synthesis programme — SuperCollider. It generates different chords when different sides of a box speaker are upright. When the speaker is held at an angle, no sound is made. Each time a side is upright, the code is re-executed allowing for different frequencies to be substituted (from a list, at random, etc). It also relies on the Python script that follows to send the accelerometer data to SuperCollider via Open Sound Control (OSC).

Thanks to Mattias Peterson, Mats Erlandsson and Daniel M Karlsson for their assistance in getting this to work.

```plaintext
s.boot;
s.meter;
{
  y = Array.series(12, 0, 1);
}
/* Synth Def. Adapted from Eli Feldsteel, Tutorial #6. */
(SynthDef.new(/iter2, {arg freq1=200, dev=1.005, amp=0, filterFreq=400, filterQ=0.6, buf = 2139, envVolAmt = 1, vol = 0.5, att = 0.1, rel = 0.1;
  // dev sets the amount of deviation for the sine waves generated by .do from the fundamental frequency
  var temp, bpfsum, ctl, sig, bufArray;
  ctl = Amplitude.ar(PlayBuf.ar(1, buf, loop:1), att, rel);
  sum = 0;
  // function generates 12 harmonically related sine waves with varying amounts of detune derived from the value of dev
  12.do{
    arg count;
    temp = SinOsc.ar(Lag.kr(freq1, {Rand(0.01,0.05)}) * (count + 1) * LFNoise1.kr({Rand(0.05,0.1))!2}.range(dev.reciprocal, dev));
    temp = temp * LFNoise1.kr({Rand(0.05,4))!2}.exprange(0.01,1);
    // randomises amplitude of each partial
    sum = sum + temp;
  }
  sum = sum * 0.05;
  sum = Mix.new(sum) * Lag3.kr(amp, 1);
  // slow fade in & out of level set by accelerometer position
  bpfsum = BPF.ar(sum, filterFreq, filterQ);
  Out.ar(0, bpfsum * ctl);
}).add;
// create 3 synths for each axis as global variables.
(~x1 = Synth.new(/iter2); ~x2 = Synth.new(/iter2); ~x3 = Synth.new(/iter2); ~x4 = Synth.new(/iter2); ~x5 = Synth.new(/iter2); ~x6 = Synth.new(/iter2); ~y1 =
```
/* Get OSC messages from Accelerometer/Python. If statements to switch chord set based on speaker alignment.set amplitude to 0 if speaker is placed face down*/

// X-AXIS
~currentX = 0;

 OSCFunc{{msg, xAxis, off, chord1, chord4}
 xAxis = msg[1].asFloat.linlin(-1, 1, 1, 100);
 // converts accelerometer data to float and then value between 1 and 100

/*choose chord combinations at random from a list of values, fundamental stays the same. nested if statement means that new value is only choosen if it is different from previous value, otherwise it selects a value each time the accelerometer is clocked.*/

chord1 = if (~currentX < 95, {
  if (xAxis > 95, {
    ~x1.set(freq1, 300, amp, 8.9, buf, y.choose);
    ~x2.set(freq1, [800, 400, 1200, 200, 1600].choose), amp, 8.9, buf, y.choose);
    ~x3.set(freq1, [100, 200, 150, 202, 402].choose), amp, 8.9, buf, y.choose);
    ~x4.set(freq1, 300, amp, 8.9, buf, y.choose);
    ~x5.set(freq1, [800, 400, 1200, 200, 1600].choose), amp, 8.9, buf, y.choose);
    ~x6.set(freq1, [100, 200, 150, 202, 402].choose), amp, 8.9, buf, y.choose);
  }, {
    ~x1.set(amp, 0.0); ~x2.set(amp, 0.0); ~x3.set(amp, 0.0);
    ~x4.set(amp, 0.0); ~x5.set(amp, 0.0); ~x6.set(amp, 0.0);
  }) }) ;
chord4 = if (~currentX > 5, {
  if (xAxis < 5, {
    ~x1.set(freq1, 200, amp, 0.5);
    ~x2.set(freq1, 400, amp, 0.5);
    ~x3.set(freq1, 200 * 9/8, amp, 0.5);
  }, {
    ~x1.set(amp, 0.0); ~x2.set(amp, 0.0); ~x3.set(amp, 0.0);
  }) }) ;

~currentX = xAxis;
chord1.postln;
}, '/x-axis');

// Y-AXIS
~currentY = 0;

 OSCFunc{{msg, yAxis, off, chord2, chord5}
 yAxis = msg[1].asFloat.linlin(-1, 1, 1, 100);

chord2 = if (~currentY < 95, {
  if (yAxis >= 95, {
    ~y1.set(freq1, 450, amp, 4.9, buf, 11);
    ~y2.set(freq1, 450 * [567/512, 9/8, 147/128, 21/16, 1323/1024, 189/128, 3/2, 49/32, 7/4, 441/256, 63/32].choose, // hello LMY
      [0.1, 0.5, 0.1, 0.1, 0.1, 0.5, 0.2, 0.5, 0.1, 0.2]), amp, 4.9, buf, 11);
    ~y3.set(freq1, 450 * [567/512, 9/8, 147/128, 21/16, 1323/1024, 189/128, 3/2, 49/32, 7/4, 441/256, 63/32].choose, amp, 4.9, buf, 11);
  }, {
    ~y1.set(amp, 0.0); ~y2.set(amp, 0.0); ~y3.set(amp, 0.0);
  }) }) ;
chord5 = if( ~currentY > 5, {
if (yAxis < 5,
{     ~y1.set(freq1, 200, amp, 0.5);
~y2.set(freq1, 400 * 49/32, amp, 0.45);
~y3.set(freq1, 200 * 21/16, amp, 0.35);
},
~y1.set(amp, 0.0); ~y2.set(amp, 0.0); ~y3.set(amp, 0.0);
})
);
~currentY = yAxis;
chord2.postln;
}, '/y-axis');

// Z-AXIS
~currentZ = 0 ;
OSCFunc({|msg, zAxis, off, chord3, chord6|
zAxis = msg[1].asFloat.linlin(-1, 1, 1, 100);
chord3 = if( ~currentZ < 95, {
if (zAxis > 95,
{ ~z1.set(freq1, 200, amp, 2.9, buf, y.choose);
~z2.set(freq1, 200 * [567/512, 9/8, 147/128, 21/16, 1323/1024, 189/128, 3/2, 49/32, 7/4, 441/256, 63/32].wchoose ([0.1, 0.5, 0.1, 0.1, 0.1, 0.3, 0.5, 0.2, 0.5, 0.1, 0.2]), amp, 2.9, buf, y.choose);
~z3.set(freq1, 200 * ([567/512, 9/8, 147/128, 21/16, 1323/1024, 189/128, 3/2, 49/32, 7/4, 441/256, 63/32].choose), amp, 2.9, buf, y.choose);
},
~z1.set(amp, 0.0); ~z2.set(amp, 0.0); ~z3.set(amp, 0.0);
})
);
~currentZ = zAxis ;
chord3.postln;
}, '/z-axis');

8.0.8 Python Script for data via OSC
This script needs to be set to run in the background as part of the autostart process detailed in section 8.0.10.

```python
import time
import board
import digitalio
import busio
import adafruit_lis3dh
from pythonosc import udp_client

# Hardware I2C setup. Use the CircuitPlayground built-in accelerometer if avail$.
# otherwise check I2C pins.
if hasattr(board, 'ACCELEROMETER_SCL'):
i2c = busio.I2C(board.ACCELEROMETER_SCL, board.ACCELEROMETER_SDA)
int1 = digitalio.DigitalInOut(board.ACCELEROMETER_INTERRUPT)
lis3dh = adafruit_lis3dh.LIS3DH_I2C(i2c, address=0x19, int1=int1)
else:
i2c = busio.I2C(board.SCL, board.SDA)
int1 = digitalio.DigitalInOut(board.D6)
# Set to correct pin for interrupt!
lis3dh = adafruit_lis3dh.LIS3DH_I2C(i2c, int1=int1)

lis3dh.range = adafruit_lis3dh.RANGE_2_G
client = udp_client.SimpleUDPClient("127.0.0.1", 57120)
#default ip and port for SC

# Loop forever printing accelerometer values
while True:
```

XI
# Read accelerometer values (in m / s ^ 2). Returns a 3-tuple of x, y, # z axis values. Divide them by 9.806 to convert to Gs.
x, y, z = [value / adafruit_lis3dh.STANDARD_GRAVITY for value in
lis3dh.acceleration]

# send accelerometer data
client.send_message("/x-axis", "%0.3f" % (x))
client.send_message("/y-axis", "%0.3f" % (y))
client.send_message("/z-axis", "%0.3f" % (z))
print("x = %0.3f G, y = %0.3f G, z = %0.3f G" % (x, y, z))

# Small delay to keep things responsive but give time for interrupt
process
    time.sleep(0.1)

8.0.9 Autostart Scripting

This script follows Fredrik Olofsson’s online guide to using Pd together with a Raspberry Pi (Olofsson, 2014). After creating the autostart.sh file, it is necessary to make the file executable (run: chmod +x autostart.sh) and then add the script to the ‘crontab’.

#!/bin/bash
python3 pd9.py &
python3 pd9-axes.py &
pd -nogui -audiodev 0 /home/pi/perimeter/main.pd

Alternatively, the system can be programmed to autostart the Pd patch via a systemd service. This has the added advantage that it can be set to reload the patch in the event of a crash. Following the guides published by The Pi Hut (2018) and the Raspberry Pi Foundation, I successfully configured the systemd service to check if the specified Pd file was running, and if not, load it.

[Unit]
Description=pdspeaker Service
After=multi-user.target

[Service]
Type=idle
User=pi
ExecStart=/usr/bin/pd -nogui -audiodev 0 /home/pi/perimeter4/main.pd
Restart=always
RestartSec=10

[Install]
WantedBy=multi-user.target

Hardware

Each ‘speaker’ is powered by a three cell lithium battery commonly used in radio-controlled sports. This sends ~12v to a small mono (t-amp) amplifier connected to the driver/speaker element. The same power source is at the same time connected to a ‘UBEC’ step-down transformer to provide the necessary 5V power for a Raspberry Pi 4B+. 
The following website includes detailed information of the design and construction including links to the specific components used, schematics and gerbers for the circuit boards that I made, and dxf files for lasercut speaker housing.

http://inventingzero.net/home/about/no-such-array/