Surface Resonance

A project submitted in fulfilment of the requirements for the degree of Master of Arts

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Declaration

I certify that except where due acknowledgement has been made, the work is that of the artist alone. The work has not been submitted previously, in whole or in part, to qualify for any other academic award. The content of the ADR is the result of work which has been carried out since the official commencement date of the approved research program.

Signature

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Online resource

This ADR will be reproduced at http://surfaceresonance.croakinglizard.com, in an html format with the text supported by images, sound and video.
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Research question and aims

My project objective was to develop compositions for installation that communicate my findings on felt and heard vibration. I aimed to create works that drew association to listeners’ past experiences and engaged with the way vibration is perceived.

At the beginning of the research program, I asked:

Through sound design and composition incorporating sensation technology, how can I use physical vibration to draw attention to the role of the body in the experience of sound, and how can I draw upon vibration in musical contexts to achieve this?

The question sustained throughout the project, and developed into four key principal research aims or foci, framing my research approach and helping to define the field covered. These concerned:

- abstracting musical basslines into an environmental domain
- articulating building materials through vibration
- composing for a tactile sensation bodily experience
- understanding the dialogue between hearing and sensation, and how felt and audible aspects affect awareness and perception of each other
Computer – multi channel audio signal outputs

Amplifier – drives the table ‘vibration actuator’ like a loudspeaker

Amplifier – for loudspeakers

Loudspeakers – generate audio for listener

Vibration table – generates vibration sensation for listener

Some sound also generated

Overview of how the vibration table is experienced
Principal approaches to research and composition

I designed a 1.2m² ‘tactile table’ system that translates sound into strong vibration that may be felt through touching or standing on it. Amplified audio signal is fed into the table, which incorporates an audio-signal driven ‘vibration actuator’ in place of a loudspeaker.

Vibration composition

I experimented with and composed vibration material for the table, exploring how an audio signal is presented through a tactile medium, and how vibration requires a unique compositional approach.

I assessed aspects such as how higher frequencies were reproduced, the dramatic changes in perceived level and upper harmonics with small changes in signal level, and phase interferences between low frequencies.

Much of my research development came from exploring the kinds of experiences and states I could communicate with vibration, and the component parts that make up an effective or engaging sensation. This helped me develop a distilled approach to composing sensation material.

Audio composition

To explore ‘vibration sounds’ from materials, I started by recording music-activated vibration in spaces. My practice developed from this to using the vibration table to ‘excite’ material into resonance, particularly large building materials such as window panes and sheet metal.

Recordings of this were the basis for acoustic composition, made to partner with the vibration material.

To make sounds through materials, I combined table-based vibration with hand dampening to alter the vibration behaviours. I also explored a range of miking techniques.

I tested the spectrum of sounds that may be generated, from metallic resonance, to discordant and distortive sound, to more subtle vibration sounds at the periphery of low frequency sound.
Vibro-acoustic presentation/installation

I explored the relationships between vibration sensation and hearing, and how when experiencing a vibro-acoustic composition, each sense can affect perception and awareness of the other.

The final works engage both the auditory and tactile senses, by involving audience interaction with the table to experience sensation, and loudspeakers that reproduce acoustic material, derived from objects brought into resonance.

I tested different vibro-acoustic relationships, such as sound and vibration aligning to each other, to more 'contrapuntal' structures.

By working with the crossover between hearing and whole-body vibration perception, and applying a range of vibration experiences and effects through the table, I developed compositions that establish a dialogue between hearing and sensation.

The initial inspiration – musical vibration and riddim

My research drew from and was influenced by environments with a strong and unique association to felt and heard vibration.

These are specific contemporary 'dance' music performance contexts, where high levels of low frequency sound (as bass in music) stimulates physical responses from the body and the architectural environment.

In particular, I attempted to capture, reference and abstract bass-line rhythm in dub and dub-influenced music. Throughout this ADR, I apply the term 'riddim' to encapsulate this concept. 'Riddim' is about powerful, rhythmic bass, with a lilting 'drop' where sensation in the body is gripped and released with different tones and intensities; and a performance space responds in different ways as it is activated by the shifting bass sounds.

By looking at this music and context as a reference point, I drew upon the unique properties of vibration within music experience, such as its strong physical aspects, and its tonal/rhythmic qualities.

I explored how effectively I can rearticulate and abstract riddim-based vibration in creation of sound art works, and tested the issues associated with this linkage to musical contexts.

I focused on the natural processes of abstraction that occur when music passes through a building and creates audible vibration; and how the resultant sound can shift from being musical to unfamiliar, or registered as environmental in nature.

While the exploration of riddim was a common thread in all of the aspects of my research, at the conclusion of my studies I arrived at a point and creative approach that was highly abstracted from this musical reference.

For audio compositions, I attempted to retain a sense of the way musical riddim activates a space, with the varying bass notes triggering different parts of a building into temporary resonance or vibration.

For sensation composition, I aimed to deliver an experience that alluded to the properties of bass-heavy riddim engaging with the body. At various stages, I experimented with stripped back, abstracted and processed bassline riddim for a bodily vibration experience.
These tests informed a broader research arc that explored other vibration sensation content that could indirectly allude to music riddim. This covered bass heavy drones, modulated low frequencies, tests with tactile feedback, and building riddim-like patterns of bass from flange and phase processing of pure bass tones.

At the end of the program, I established effective approaches with slowly undulating vibrations.

**Conclusion of the research program**

To most effectively answer my research question, I concentrated on testing and developing new understandings within less explored aspects of a broader domain.

For example, my compositions are in the realms of full-body *tactile* and combined tactile and audible experiences, while recognising the work of artists exploring low frequency *sound* sensation. With sound, I concentrated on generating, articulating and recording surface vibration, with an appreciation of the artists and works investigating space and object resonance.

In concluding my Masters program, I have:

- thoroughly explored my research question and aims
- contributed new works and ideas within the larger field of sound art employing low frequency sound and vibration
- developed a solid basis for a broader practice that can build on my findings and contribution to the field
ii. Contribution to the field

This section describes the relationship of my work to others in the field. I separately describe the aspects of the vibration sensation experience, making sound from vibrating materials, and the combined vibro-acoustic experience.

The key elements that situate my work and mark its contribution within the field are provided first. Following this is an outline of other cited artists and works within the broader domains of tactile work and vibration sound.

Contextualising the work

Vibration sensation experience

The central body of my work concerned understanding and composing for the tactile experience. This was for both vibration-only and vibro-acoustic works. I used the vibration table as a means of communicating vibration and also as an instrument itself, focusing on its particular attributes as a sounding device.

My compositions for a deep, very low frequency bodily experience have commonalities with a number of sound artists [for example, Randy Yau and Scott Arford’s Infrasound performances, Zbigniew Karkowski, Francisco Lopez], as well as connections to deep bass sensation in riddim music (dub, drum and bass, dubstep etc.) and other deep sensory music and experimental performance artists such as Sunn O))) and Cat Hope / Lux Mammoth.

The fundamental difference between my work and the rest of this domain is the different experience and compositional language I offered through explicit tactile sensation, compared with sensation as a product of low frequency sound.

While there is a broad crossover in the experiences, there is a very different textural scope in tactile sensation, with many gestures and experiences not being translatable from one sense to the other. My research is underpinned by my interest in this relationship, including understanding the crossover between sensation and sound perception.

My decision to use the table as a standalone, portable sounding sculpture aided this concentrated exploration of sensation experience. It offered a way of developing and expressing ideas that were not reliant on stimulating whole rooms through massive audio systems. The participant experience was more internalised and personal than architectural.

I composed a broad range of vibration gestures, developed targeted approaches to making source material with sensation as the primary aim, and worked with the specific vibration and audible characteristics of my constructed table, as an instrument.

I am aware of, but have not been able to directly experience, the work of other artists using body tactile transducers [for example, Patrica Piccinini’s the breathing room, Recombinant Media Labs, Michael Luck Schneider and Bruce Odland’s work, including for the Good Vibrations Caravan].

Compared to these artists, I consider that by working with a dedicated vibration device, in a long-term experimental sense, rather
than in an installation or for a performance, I have been able to offer new experiences for audiences.

This is particularly the case where I have focused on discrete components, including rhythmic elements, stutters and plosive effects, rather than longer arcs, such as modulated sine tones, which, from my readings and discussions in this area, I understand are more typically employed in installation works.

Also, I have focused on vibration as a standalone experience, rather than using vibration devices to deepen an existing audio or audio-visual experience, as appears to be the case with some cited installations. It is in such areas, and the research around separating the vibration and acoustic elements from their normal bound relationship (see below), that I have contributed to the field.

Perhaps the most relevant artist in this area would be Mark Bain, who uses transducers and complex vibration tones to activate performance spaces into vibration. In these installations, the connection between architectural vibration and tactile vibration would be most explicit.

**Making sound from vibrating materials**

When approaching sensation I focused on an internalised tactile experience delivered through the table. This focus extended to the way I approached the excitation, manipulation, recording and presentation of vibrating materials. I used the table to generate vibration, and shaped sound in a close and personal, bodily interactive sense, rather than a spatial / architectural sense.

I have developed my own compositional practice of articulating materials through bodily engagement with vibration. For example, to shape vibration sounds I applied my body weight and pressure across large vibrating surfaces such as window panes and sheet metal.

(Conceptually, James Tenney’s *Koan: Having Never Written A Note For Percussion* guided my focused exploration of the changed state of surfaces as they are subjected to different intensities of vibration stimulus.)

This process was about expressing the potential for surfaces to be excited into vibration. This vibration can be a harsh, discordant and inharmonic type of sound, that is by its acoustic behaviour inherently and harmonically tied to the deep sound or vibration that has caused it, and underpins it.

My approach of hand dampening to ‘contain’ the vibration sound has enabled me to skirt around the edges of discordant vibration, and express a potential-vibration state.

This control, combined with the use of varying and complex vibration tones, provided a different character and depth to the sounds than what is achieved through single-frequency vibrators or offset motors, such as in David Byrne’s *playing the building* installations.

The sounds created are also largely different to the object-vibration works I have cited, which have tended to use smaller scale materials (see ‘artists and works’ below).

The aesthetic also contrasts with sound-making using percussion (striking) to generate sound, such as in the glass percussive works of Eugene Ughetti.
The vibro-acoustic experience

The preceding information outlines the primary components of my investigation. However, my composition-led research may be best understood through the combined vibro-acoustic experience I offered to an audience.

To make sound and vibration I developed content that referenced the ‘bound’ experience that occurs when deep vibration travels through a structure and into the body, and what this evokes in a listener.

The music environment, as a starting reference point, is an example of where high intensity, low frequency sound stimulates buildings and bodies into vibration. In this situation, the ‘bound’ experience of sensation and audible building vibration of large materials is most explicit.

Drawing from this experience offered a perspective into the spectrum of situations where low frequency waves stimulate the body and architectural structures into resonance and vibration (whether a musical, vehicular, environmental or mechanical source), sometimes in ways that are barely perceived, or noticed only in passing.

My approach involved making sound from large building materials, such as window panes and sheet metal. This focus helped me to maintain a clear reference to the vibration sounds caused by music within a performance space, and to explore the other low frequency resonance and vibration sound contexts.

By focusing my audio compositions on expressing the range of sounds that can occur from ‘activated’ building materials, and making these an integral part of a bodily experience, I was able to tap into an existing frame of reference and ground the audience experience.

In the sections above I describe linkages from my work to artists using intense low frequency sound to activate spaces and bodies [Infrasound etc.]. These areas have much in common with my approach. However, previously described, I have explored a more internalised, personal experience by targeted stimulation of materials, their recording and their reproduction in an installation context.

This enabled me to contribute new works with a finer control over the sound / sensation dialogue, including controlled expression through the table and the materials it stimulates.

Importantly, my work involved separating and challenging the traditional or expected sound-sensation relationships (i.e. those made where sound creates the sensation and the vibration-sound, as parallel aspects of the same experience).

Using the table alongside pre-recorded vibration sound enabled me to play with a range of vibro-acoustic relationships, including synched, ‘contrapuntal,’ and more subtly separated approaches. This offers new experiences for an audience that draw focus to our ordinarily subconscious perceptual processes.
The broader field

Artists and works - vibration sound

In considering this area, it is important to make a broad distinction about the areas of vibration and resonance that I have focused on.

As previously described, I have drawn from and referenced works and situations where deep low frequency sound activates spaces and bodies into vibration. This use of intense low frequency sound in a space also crosses into the area of expressing room resonance, as emblematised by Alvin Lucier’s *I am sitting in a room*, and works referencing this approach such as Jacob Kirkegaard’s *4 Rooms*.

However, I have chosen to concentrate on object vibration and resonance of surfaces (as parts of a space), rather than this architectural resonance (such as standing waves) aspect. The following describes inspirations, works and artists in the field of object vibration and resonance.

All of these are areas of interest, some of which I intend to explore further in my future practice. My particular approach has acknowledged the strength of work in this area and focused on less explored approaches and materials. In doing so, the sounds and aesthetic I developed do, in part, offer new experiences within what is a well-explored domain.

The chosen approach and materials have also been integral to addressing my research objectives around the combined vibro-acoustic experience and how this can draw from real-world experiences of body and object vibration.

An initial source of inspiration was the way that basslines in music could create vibration in spaces and loudspeakers. I drew from the work of producers that embrace a ‘distorted’, vibration-like aesthetic in their bass compositions [for example, Jah Warrior, The Bug, Scorn]. I was also interested in producers working with abstraction of the rhythm of drums and bass [for example, Hrvatski, The Artbreaker].

This connection extends to other bass driven rhythmic compositions outside of a direct musical sphere [for example, Carl Michael Von Hausswolff’s *Strom*], including works of Koji Asano exploring the properties of loudspeakers as a prepared, distorted or torn expresser of sub-frequency energy.

From this reference point, I was interested in a range of work in the area of smaller prepared objects activated into vibration through loudspeakers or vibration transducers, such as Untitled Sound Objects’ work with metal plates, beads on a surface, and vibrating paper; Jeff Jerman’s *Instability Studies* with ‘shaketables’ and exploration of vibration and harmonics in instruments and materials by Tim Catlin and Jon Mueller. Vibration and resonance in objects is also richly explored field recordings, in particular by Toshiya Tsunoda.

I have also cited a work *Clicks and Cars*, by Foton, using vibrators to excite car frames into resonance, although I understand that this did not involve body or hand articulation.

My approach to building sound/sensation compositions gravitated around an underpinning deep low frequency sound/vibration, and building upon this, upper harmonic (and inharmonic) audible material.
made from the excitation of objects. An initial inspiration for this ‘fundamental frequency’/‘harmonic’ thread within my work were works and interviews with Alan Lamb, on the resonance of telephone wires.

**Other fields of research and application**

From a research perspective, whilst my work contributes to current knowledge in scientific research for music applications focused on the sound/sensation dialogue (see background below), my personal approach was to use knowledge in this area to facilitate creative expression, rather than to add to current academic texts.

The use of tactile transducers has obvious relationships to a range of other applications for vibration devices. These include gaming, theatre and nightclub applications. However, my compositional research was much more acute that the typical ‘commercial’ applications where sensation is an augmentation or supplement to the overall experience of sound and/or vision, or a basic shaking or explosive effect for the authentication of activity.

Being designed for the whole body, my area of work also differs from use of tactile transducers for communication by more localised touch (such as the hand held dual shock controllers in computer game systems). Early research enabled me to distinguish my work from this area from an academic viewpoint (also see background), as the modes of communication and experience are very different from each other. For example, engineering texts make a categorical distinction between hand and whole body vibration, as one is more to do with touch, and the other body effects.

Finally, my vibration work has commonalities with vibro-acoustic therapy, an area where deep relaxing sensation is used to treat patients with sensory impairment or other physiological difficulties. While not within the realm of my research question, I would eventually like to explore this area further.
iii. Background

The sound art research program developed from applied research into low frequency sound and sensation perception. I was interested in the way the body processes sensation and the dialogue between the senses.

This section is a reference for discussion of vibration perception within this ADR. It constitutes the findings of research undertaken before the commencement of Master of Art studies.

The Master of Art candidature developed from a Graduate Certificate and preliminary Masters research at the Spatial Information Architecture Laboratory (SIAL).

The initial focus was on using floor-based vibration as a substitute for subwoofer sound in a nightclub setting, and the noise reduction benefits this would offer. I later moved departments to refocus my work on the creative potential of vibration technology.

This background research included:
- Relating soundscape studies to the experience of low frequency sound in contemporary music culture
- Researching sound therapy, sound perception and engineering / noise studies on low frequency sound and vibration
- Prototype design of a small, low frequency sensation generating floor, and testing with a group of participants

Research findings - vibration and vibro-acoustic perception

The purpose of my research in this area was to broadly understand aspects of vibration perception that could inform my approach to composition and installation.

Vibration perception

The processing capacity of the tactile system has been explored in detail through research with an industrial/noise focus, with key literature broadly distinguishing between finger transmitted and whole body vibration.\(^1\)

The 'loudness scale' for vibration differs to that of sound\(^2\), i.e. an equal increase in the dB level of vibration and acoustic signal won’t lead to the same perceived increase in level across both senses. The vibration response can be understood to generally be more ‘linear’ with stimulus increase, whereas hearing perception is more like a ‘logarithmic’ function (as equated in the dB scale for sound pressure and audio signal).

Comparison of airborne with structural vibration is an emerging field,\(^3\) and research and anecdotes around low frequency sensation from soundwaves cannot be assumed to transfer to tactile/vibration perception.
Some vibration studies were not directly relevant to the whole body vibration focus of my work, such as those of haptic feedback for fingers or hands or skin effects. However, I concluded that these could still be relevant to understanding the way people process and perceive vibration in a whole body vibration context. For example:

- With skin vibration, different frequencies carry different subjective effects, such as a buzzing vs a smooth experience
- People have limited capacity to discriminate different frequencies through skin vibration
- Perceptual effects can occur depending on the type and closeness of vibration impulses. For example, depending on the timing of impulses, the vibration experience may be enhanced, or signals may appear to be summed together or suppress or mask one another.

Vibration and auditory interactions

There is substantial frequency-range cross over between the active range of vibration and auditory senses, with hearing extending below 20Hz (with loss of tonal perception), and vibration ‘effective’ at a range of frequencies, depending on its source and the type of body connection (i.e. skin, whole body or finger).

Compared to the auditory sense, the tactile sense is relatively lacking in sophistication.

Studies on perception of timing\textsuperscript{6,7,8} of musical auditory/tactile events found that:

- The auditory and tactile systems have different processing delays before the signal is recognised by the brain, with sensation taking longer to process
- People will discriminate when the vibration and acoustic events are not ‘simultaneous’, and may find this distracting

- The perception of simultaneity is not absolutely precise. Within a tolerance range (measured in milliseconds), sound/vibration events do not have to be exactly simultaneous to be perceived as such\textsuperscript{9}
- The envelope of a sound has a significant effect on the timing requirements for perceived simultaneity,\textsuperscript{10} with a more gradual envelope reducing perceptual discrimination of timing offsets
- One study used an interactive touch/feedback sensation with an acoustic system in a virtual environment. Increased acoustic level made people think the sensation level had increased.\textsuperscript{11}

Vibro-acoustic therapy and tactile systems

Vibro-acoustic therapies offer a range of positive physiological and psychological effects that come from vibration stimulation to the body (usually while listening to music), such as relaxation to muscles, pain relief, assistance with brain disorders and injuries, and other rehabilitation benefits.\textsuperscript{12}

Vibro-acoustic therapy tends to use vibration that either reproduces the low-frequency parts of music, or uses pulsed sinusoidal tones (such as from beat frequencies), in line with the principle that ‘exposure to soft, low frequency and non-rhythmic music... results in physiological responses indicative of relaxation.’\textsuperscript{13}

Significant levels of high frequencies through a vibro-acoustic system can lead to undesirable or distracting acoustic noise.\textsuperscript{14}
When used in a vibro-acoustic system, the vibration signal needs to be electronically compressed (dynamics reduction) to perceptually align to the acoustic information.\textsuperscript{15}

**Vibration floor testing**

The vibration floor and soundsystem tests explored how people respond to different frequencies and intensities of low frequency sound and vibration.

In each test, audio material was sent as sound through a large subwoofer and loudspeakers, and then sent through the vibration floor instead of the subwoofer.

I interviewed participants about how the sensation experiences differed, their general observations of the sound and their spatial and bodily connection to it.

Testing used swept (fixed or pulsed) sine tones, and a selection of bass heavy music with contrasting frequency content.

The vibration/acoustic setup and ‘tuning’ applied findings from my journal research. For example, I used:

- Equalisers and crossovers, to reduce unwanted high frequency noise through the floor, and roll off the acoustic level to enable a smooth transition to sensation (crossover point \textasciitilde70Hz)
- Compression of the vibration floor signal, to match the perceived vibration and acoustic
levels
• Delays, to account for timing offsets from the distance from the loudspeakers to the floor, and sensory processing differences.

I refined these parameters through participant feedback, and found that the ideal settings accorded well with what was suggested through other research.

The following test outcomes were the most valuable to the ideas and methods I took to sensation composition during the Masters research.

Appendix A details these and other general findings and the testing process.

Comparing modes of presentation

Using the vibration floor did not simply replace the acoustic energy with a more direct sensation interface. The qualities of sensation were fundamentally different, being more grounded in the body.

Overall, at most frequencies participants found that they were more comfortable with vibration energy than with the acoustic only system. However, in the higher bass frequencies acoustic and vibration energy became more similar in sensation qualities.

Vibration sensation ‘bodily placement’ (localised sensation) did not correlate with findings from the acoustic only system, suggesting that the way the body is excited by direct vibration is significantly different. Some effects were specific to the vibration system, such as a sense of the feet shaking. The range of sensations experienced were broad, including effects in the upper body, face, legs and back.

In most tests the acoustic only system was less enjoyable for participants. Because the acoustic energy did not involve the body as directly, low frequency information was less tangible and less defined.

Comparing to the vibration floor setting, the sound-only setting led to additional reverberation of low frequency sound within the space. This significantly ‘muddied’ the overall sound experience.

Interesting perceptual responses to sensation

The testing suggested unique perceptual quirks when people experience sensation as vibration.

Participants reported the sensation as moving around the body with different frequencies, skin sensation, a sense of vertigo and a feeling of tiredness occurring with specific frequencies, and perceptual placement of frequencies within the room.

However, these responses were not consistent between participants, and there were not specific frequencies with predictable effects. I suspected that testing in open spaces or specially designed testing environments may have provided more consistent results.

Participants engaging with the direct sensation

Most participants quickly found that they became more involved with music when the vibration floor was engaged. In addition to compelling more attention to the music, the floor itself became something to interact with and was missed when deactivated.

Descriptions included: the floor creating a nicer experience because sensation was more
bodily, feeling more involved and consumed, increased awareness of high frequency sound (in its relationship to the sensation), increased awareness of low frequency sound, quick association with the vibration experience, and that the floor created another level of interaction or relationship.

**Frequency**

Each music test track had a different frequency emphasis. Participants favoured pieces with frequency content extending into the very low frequencies (20-45 Hz), where the contribution of the floor was felt to be more essential.

Tracks where frequency emphasis was centred closer to the upper operating frequency of the floor (~85Hz) still benefited. However, vibration effects were noticed as 'buzzing' or were perceived to be located in the floor, rather than a logical extension of audible sounds. This may have been partly due to the type of technology used (modified loudspeakers rather than dedicated vibration actuators).

Participants found that when the low frequency information was distinctly different from high frequency information, the floor failed to enhance the music experience. Rather, with auditory and vibration senses processing separate information, the floor became a distraction and could be disorientating due to lack of cohesion.

This was primarily noticed on one track, which had an atypical gap in information between low and high frequencies. All other tracks contained some degree of acoustic ‘artefacts’ in the upper harmonics of the predominant (vibration sensed) bass information, which possibly aided in tying sensory information together.

**Envelope**

Participants favoured the vibration interface in tracks where low frequency rhythm was not overtly punctuated (i.e. having a rolling or fuzzy quality). More punctuated rhythm appeared to highlight differences between acoustic and vibration information, perhaps because the chronological space of definite ‘beats’ promoted more critical perceptual processing.

This result was consistent with the findings of William Martens on envelope and timing delay tolerances.16

**Dialogue between the senses**

Feeling the bass as vibration sensation ‘muted’ auditory sensitivity to the complementary sound. Most participants did not perceive acoustic energy in the room until acoustic levels were much higher than the normal perceptual thresholds.

With sine tests, most of the participants identified the same frequency point (56-57Hz) where the energy shifted from vibration to acoustic borne.

However, while this correlation was notable, I suspected it was influenced by the specifics of the testing room and audio setup. For example, room modes and resonances, and the slightly uneven frequency response of the loudspeakers at the crossover points would have affected the audio levels around the room, depending on the frequency.

One participant identified a frequency where they felt that their focus was flipping between the vibration and acoustic system, at a point...
where both energies were perceived to be at similar levels. This suggested that, although there is some degree of perceptual blending with combined vibration/acoustic energy, the potential exists for sensory confusion when the two sources of information are similar.

Similarly, tests with music tests tracks suggested that vibration and acoustic perception, although working together, can compete with and affect each other, and this effect is dependent on the frequency make-up of each source. For example, the frequency focus of the bassline, the transition from low to high frequency content, and the type of frequency gaps between the very low and mid-high frequencies will all influence the results.


3. William Martens, personal correspondence.

4. Verrillo, 1992


13. Hooper, 2002

14. Dalgarno, 2000

15. Dalgarno, 2000

16. Martens, 2005
Phase 1
Collecting vibration sounds, composition basis in riddim
Feb 07 – April 07
My first project was to take field recordings of music-based vibration around nightclubs.

Although the recordings contained good examples of vibration, I found that the overall sound was too obviously taken from a nightclub/music context to be of use. When listening back, the other musical elements were very predominant over the vibration.

In response to this issue, I explored ways of emulating this experience in a way that would accentuate the characteristics of musical vibration that were of most interest.

I generated content by looping a drum and bass bassline, and applied processing to try to filter and abstract the explicit musical aspects of it. I then played the processed sound within a space, through a large PA, and recorded the effect this had on the space.

I based a composition around this. The recordings were further processed, such as through time stretching and layering, to further abstract from the notable sense of rhythmic pattern still underpinning the source material. To further abstract the work, I also incorporated ambient recordings of mechanical and electrical low frequency sound.

Questions and research outcomes

I explored two of my principal research aims:

- 1.1 - Abstraction of “riddim” – basslines moving from musical to environmental
- 1.2 - Low frequency sound activating spaces - articulating building materials through vibration

From field recordings, I had a better understanding of how vibration sounds, how it is created and relates to low frequency stimulus, and how to record it. I realised its complexity and the limitations and challenges of trying to emulate it through software.

I compared the 'live' experience of being in a space activated into vibration/resonance by a large PA, to recordings of this space and process. It was clear that much of the 'live' experience would never translate to recording and reproduction. This was mainly because the sensation and strong low frequency presence in the space required a powerful audio system with extended low frequency response. Also, the overall sound came from a summation of the many resonances and vibration responses throughout the space, which would require sophisticated recording techniques to capture, and would likely be more interesting as a live effect.
I considered this issue and that the other artists I knew of working in the field were using large PAs in performance to create vibration [for example, Randy Yau and Scott Arford, Zbigniew Karkowski].

I resolved that for my Masters project I would explore alternative methods, suited to loudspeaker reproduction, that would offer listeners a sense of the vibration in spaces without a reliance on big PA setups.

I considered that this would create a more internalised and translatable experience, in keeping with my focus on the perception of vibration. It would also enable me to focus on the range of ‘vibrations’ that could be made from materials, rather than thinking of vibration as an interaction of sound and space in a live performance. This thinking directed later research.

Using music-based recordings, I employed many techniques to blur riddim but the musical link/pattern remained. This presented an ongoing challenge and made me consider what relevant alternate approaches I could use to heavy bass generation.

The use of more ambient material developed my creative process and helped me explore the idea that vibration potential is inherent within materials, subject to low frequency stimulus.
### Phase 1

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Phase 1 research on abstraction of riddim centred on controlled recordings of partly blurred/abstracted basslines, and further work in the studio, to understand and address issues with using such a music-based source.

Tests with a large soundsystem

To blur riddim and record the effect of sound on a building, I developed music-based bass material, and reproduced this through a large (2 x 15" drivers) subwoofer, situated in a house.

The material started with looped basslines from tracks that I had experienced as creating powerful vibrations before. I focused on one track in particular, *Rwanda* from Smith and Mighty/Mighty Rockers. I chose this early drum and bass/dub crossover track because of its low fundamental frequency, smooth transitions between notes, and rich tonal/upper harmonic content.

I used a range of basic effects on this track, selected because of their parallel to the natural processes that low frequency sound goes through in its passage through a space.

I used a low pass filter that started out very low (20Hz) and worked up to 180Hz. This enabled a focus on the lowest aspects of the music, and how the different frequencies would affect a space.

This filtering also paralleled the way that a building acts as a natural attenuator of higher frequencies, so that the lowest sounds (and the effects of them on the building fabric) are all that is heard outside the space.

I combined this approach with reverberation, which I employed thinking about the experience of hearing music in warehouse parties in industrial complexes, where the bass sound becomes ‘fudged’ from reflecting against building walls across a large space.

The use of these effects meant that, aside from the core rhythmic repetition, the musical elements were obscured. This enabled my aims of finding a point where musical sound merged into something that is registered as more environmental.

Heartical Hi-Fi, reggae soundsystem

One of the black boxes (2x15”) was used
Listening to the processed sound in the space was deep, atmospheric and very submersive. The overall sound, being based on music, captured well the in-between musical/environmental sense aimed for.

However, listening back to the recordings on headphones and smaller loudspeakers emphasised that this experience does not translate without the powerful audio system. For example, the rhythmic elements, while smoothed/stretched by the interaction of loud low frequency soundwaves in the space/body, were more distinct and obvious when listening back in an ‘ordinary’ context.

Despite this, both the actual and recorded vibrations elucidated the sense of ‘building response’ I was interested in, where particular building elements responded to different bass frequencies, and respondent vibrations ‘tailed’ the bass sound. The focused process of contriving and recording a sound/vibration relationship helped me better understand the way spaces respond to vibration and the transformation of riddim within a building.

**Processing recordings to disassociate the bassline + environment**

I made a composition with the materials gathered. I wanted to disassociate from the obvious rhythmic elements of the PA recordings, and make an acoustic piece that evoked the sense of being in a bass/respondent vibration space, without reliance on large equipment to achieve this.

I started with three recordings taken from the engineered soundsystem/vibration setup. The phrasing of all of these was matched, being taken from parallel/repeat processes of playing back the low frequency sound track and recording it in the space.

Once layered together, I processed the sound to disassociate the recording from sounding like a site recording, and being overtly rhythmic. This included distortions, tone emphasis, and changing levels and frequency filtering to create interactions and progressions between the tracks, bringing out and focusing on particular tones and elements within a constant piece.

I found that there was a remaining challenge in that despite these changes, there was an underlying semi-constant rhythmic element, even if quite removed from the original source. This appeared to be a potential distraction, or too strong a focal point.

In response, I copied and time stretched tracks to change their patterning, and further experimented with volume interactions between different timed tracks.

This had moderate success but questions remained about the tension point created by rhythm in the exploration of music/environmental crossover.

While use of riddim posed this challenge, the testing and composition process drew my focus to the opportunities and areas of interest that riddim offered. For example:

- how tone changes activate different materials
- how pulsed sound triggers a response from vibrating materials in ways that drones do not
- how my composition might evoke a musical experience (and whether I wanted this).
Adding atmospheric low frequency material

At this point my thinking moved into how a composition might evoke the ‘atmospheric’ as opposed to the ‘musical’, and how to draw on the natural/environmental instances of powerful low frequency sound to achieve this.

I took recordings around the Merri Creek area. The area was chosen as urban activity and technology presented sources of distinct low frequency sound, against a relatively quiet natural backdrop.

Locations where low frequency sound was a dominant characteristic included an electrical substation, under bridges that resonated from the energy of vehicles, and under a train station, capturing the arrival and departure of trains.

These elements were incorporated within the riddim-based composition.

I used a process of spectral convolution, which is the multiplying of tone and amplitude information between two tracks (with the ambient recordings being the source, multiplied with the vibration recordings from the riddim experiments).

This resulted in a ghostly, tonal and resonant effect, with spectral familiarity to the riddim recordings.

This process enabled me to explore the idea that all low frequency sound has a resonance and vibration potential, and that subject to the right respondent physical environment, that any low frequency sound could create a vibration response.
Nightclub recordings

My first approach to capturing bass-induced vibration was to take recordings outside nightclubs.

Background research included seeking advice from online music communities and promoters about venues with bass vibrations. After surveying sound from eight potential sites, I focused my recordings on two venues with the most obvious vibration characteristics.

At the first venue, Brown Alley, the music was dub/drum and bass. After investigating the bathrooms, stairwells and service areas, I took recordings from the windows and doors of the venue. These were located near to the subwoofers and offered clearly punctuated mid-high frequency vibrations.

At the second venue I used rooftop access to a nightclub with house music and recorded the rattling of the metal sheeting and fixtures.

The recording process helped me better understand the acoustic characteristics of vibration.

When recording sound from a window or door, the timbre would change dramatically depending on where the microphone was placed. The distance from the source made a big difference, as the sound became less ‘aggressive’ or ‘sharp’ with distance.

This recording process also clarified how complex vibration sound is. By using close miking techniques, I could hear the way the whole panel of a window or door vibrated in different ways across its surface. The overall sound was made up from the composite of these vibrations interacting and supporting each other.

This finding cast doubts about how effectively I could ever synthesise vibrations through Max/MSP, especially for more complex objects such as panels. It did however suggest that if I was able to take clean recordings of vibration sound, and process these into very small samples, they may be able to be used in wavetable synthesis.

Setting up and recording vibration with soundsystem

The testing of blurred basslines through the large PA (see abstraction of riddim) also involved experiments with how to best record the resultant vibrations in the space. I tried different placement distances, and using stereo pairs vs close single miking. Close miking seemed to offer the best result, as it picked up the higher frequency sounds.

I also deliberately set up vibrations, by placing glasses and cups next to each other. The sound was generally not as interesting as wall/panel vibrations, because the sound source was quite obviously identifiable, and the vibrations didn't seem to ‘match’ to particular bass notes to the same extent a wall resonance would.
Max/MSP work, emulating and controlling vibration-like sound

During this time, I also attempted to build a Max/MSP patch to emulate the sound of vibrating materials. The idea was to use generated or recorded low frequency sound, and design sound software to ‘respond’ to such sound when at an appropriate level/frequency – generating a sympathetic vibration sound in response, which could be controlled and spatialised.

The project included:

- consultation with a vibration acoustics specialist, Jim Minnague, who explained some of the physics of vibrating surfaces
- online research and seeking assistance from Max/MSP forums, and acoustics groups
- trying to develop Max/MSP processes that copied the ‘real-world’ physics of vibration (for example, the modelling processes of Perry Cook)
- searching for acoustic data of resonating materials, such as their spectral makeup
- looking at how to generate content based on such real world data, such as additive synthesis from broken down samples of vibration (application Spear)
- looking into wavetable synthesis as a means of making sounds
- phase control of short sinusoidal samples

This understanding was the basis for the Max/MSP programming, and also informed my later approaches to composition, such as thinking about thresholds in level above which vibration or distortion would be activated.

I dropped this arduous programming process after some months, as I realised that vibrating material sounds were far too complex for me to emulate, and recordings offered more interesting source material that I might be able to control in a way similar to the Max/MSP intent.

This technical process helped me to understand the physics of vibration. A material will oscillate in sympathy with low frequency sound, until its range of movement is ‘truncated’ by its physical boundaries (for example, a window pane in a loose frame), at which point it abruptly ‘clips’ and generates non-periodic harmonics based on the original activating frequency.
Phase 2

First experiments with the table as an instrument

May 07 – July 07
I found that the layers of processing used in the Phase 1 composition had reduced the dynamics and immediacy I sought from vibration sound. To resolve this issue, I sent bass information from the composition through a bass amplifier and the vibration table, to excite small objects into vibration. Recordings of the rattling objects were added to the composition. This marked a shift from using vibrations in recordings to generating and controlling vibrations ‘in studio’, and opened up the type of sounds I could use, with greater control and isolation from other noise.

I progressed to using the table itself as a sounding device, with a range of tests around using the table surface to generate audio, and the way audio signals would behave when applied through the table.

I started using drones and modulated bass through the table, as a departure from bassline riddim.

**Overview of research outcomes**

I explored all of my principal research aims:

- 2.1 - Low frequency sound activating spaces
  - articulating building materials through vibration
- 2.2 - Tactile system as an instrument
- 2.3 - Abstraction of “riddim” – basslines moving from musical to environmental
- 2.4 - The dialogue between hearing and sensation - felt and audible aspects affecting awareness and perception of each other

This phase concluded with a presentation and discussion with the Sound and Media Arts postgraduate students in the Sound Studio at RMIT. It helped me think about the framework in which I wanted to compose. I solidified my interest in installation, with sensation, as a key focus over performance. The main findings follow.

Using the loose MDF top of the table as a large vibrating source offered a unique sense of control and ‘playability’ for vibration sound. I could use my body to change the pressures across the surface to manipulate the vibration.

The large surface also offered a range of approaches to miking, with the sound character varying significantly depending on microphone distance and placement across the surface.

I found that vibrating surfaces were also unpredictable in terms of the sound generated. I was challenged by the way sound would quickly transition from neutral to noisy.
and discordant, and recognised I needed a framework for generating sound that offered a greater degree of control.

I began to understand the unique attributes of sound as reproduced through the vibration table – how upper harmonics would dramatically reveal themselves with incremental increases in volume, how distortion of the electronic signal could artificially emulate the way that vibrating materials ‘distort’, and the frequency range best suited the table.

I started using drones from my bass guitar as a signal for the vibrating table. It diverted from the riddim approach, and the organic source, with rich harmonic content, had an interesting combination of a deep drone, and high frequency content that engaged the body. I found very low frequency modulation (a shaky sort of feedback) offered significant sensation effects.

At the end of this phase I was motivated to explore a greater range of vibrating materials, as while the MDF was interesting in its playability, it was not very interesting timbrally.

The sensory/feedback experience of playing the table also refocused my aim to bring sensation to an audience. Hence I decided on an installation approach over performance.
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Research findings:

- I want to create sense of the vibration in spaces without reliance on big PA setups
- Recognise potential for playing the table and found bass guitar drones as suited to generating sensation and sound
- Focus on playability and expression around drones and modulation
- Understanding unpredictability when using the table this way and desire for structure to how I approach composition
- Playing the table refocused my aim to bring sensation into the audience experience
Simulating vibration from composed material, using bass amp and vibration table

Listening back to the preliminary composition (see Phase 1), I found that the work was flat, partly due to a lack of dynamism and immediacy in its layered and processed sound.

Responding to this problem, I played the low frequency components of the composition through a bass amplifier and the vibration table, on which I placed objects such as glasses and coins. These rattled together, offering a more ‘live’ and direct acoustic element, which was recorded and added to the composition.

These steps motivated me to explore studio-based vibration sound, as a controllable way of capturing the sense of object vibration.

First experiments with the table as a sounding device – larger scale vibrating material

After the small object works, I dismantled the table top from its frame for maintenance. As the MDF top was ‘floating’ on the frame, undampened, it was predisposed to various harmonic rattles when low frequency vibration was sent through the steel understructure.

Interested in this effect, I tried a number of sessions to see what basic elements changed the harmonic and timbral response of the table.

Firstly, I walked on the surface and found that by applying targeted pressure I could dampen the vibrations, controlling and shaping the vibration sound.

Next I explored how vibration results would change with simple variations to the sonic material sent through the table. I used a basic three-tone rhythmic pattern with varying amplitude, and found that increases in volume would activate more of the upper harmonics in the MDF, and that results would vary markedly with small changes in level.

I extended from these tests by setting up a passage of vibration, where a shifting bandpass filter focused the signal of the rhythmic pattern to a frequency range. The filter started at 20 Hz and moved upward to 100 Hz over the course of a few minutes, slowly opening up the upper harmonics. Over three sessions, I experimented how different approaches to surface pressure would interact with this sequence.

Firstly, I left the table ‘neutral’ letting the natural vibrations occur as I increased volume and frequency range of the signal. While rattles became more tonally complex with additional high frequencies, they mainly sounded like ‘noise’ of an object than something with deliberate tonal structure. The results were more chaotic than expressive.

I next applied different approaches to hand ‘pressure’ on the table surface. I found that deadening some vibration points (anti-nodes) would tend to amplify others, as those parts
of the surface were less constrained or had a greater gap from the frame. This led to loosely controllable localised vibration effects from the interaction between frame and surface.

Finally, I experimented with applying ‘upwards pressure and release.’ I lay underneath the MDF and lifted sections of the perimeter, but squeezed downwards at the same time from a different location. I also used knives jammed into the frame to change the points of contact between table and frame.

This approach offered better control of the vibration sounds, as there was a balance between different vibration points, without one area of the surface rattling too strongly. I enjoyed articulating the sound by changing my physical interaction.

Overall, the recorded results highlighted limits to using the MDF table surface. The passages didn't offer much of a sense of tension and release. The palette was clearly limited, as quiet phases were not gentle or particularly subtle or beautiful, and 'noisy' phases were not alarming, aggressive or spectrally exciting. These sorts of limitations suggested the need to work with other materials.

However, the experiments helped me think about the table on the whole as a sounding device. The process and results suggested its potential as a malleable instrument that one could actively 'play' at a large scale, using body pressure.

This testing was also instructive for microphone technique. There wasn't an obvious best way to record the table, as while close miking provided a more immediate sound than placement away from the surface, it didn't pick up some of the vibration points. While I mainly used stereo microphones very close to the centre of the table, I considered that in future I would try multiple microphones, or multiple recordings in different locations across the surface.
Phase 2

2.2 - Tactile Instrument

First experiments with the table as a sounding device – larger scale vibrating material

The first tests (Phase 2.1) with putting a three-tone rhythm through the table highlighted differences between normal audio compared to sound when reproduced through the table.

Most notably, small increases in signal level led to dramatic increases in the level of upper harmonics. High frequency elements would jump out in steps, even when the increase in signal level was smooth and incremental.

I also found that lower level signal would be quite ‘noisy,’ with a lot of unwanted sound generated even with a clean signal fed into the table. At higher levels, the dominant vibration tones would overtake this noise.

It appeared that these responses were a result of both a) the vibration actuator itself, and how it functioned as a quasi-loudspeaker, and b) the physical structure of the table, being a heavy metal and wooden frame, rather than a delicate tool like a paper loudspeaker driver.

Understanding these limitations in dynamic range and use of level helped my later approaches to composition and testing, such as in the work gutterglass (Phase 3).

The table also showed a poor reproduction of higher frequencies (above ~90Hz). These came through at a lower level relative to deeper tones, partly because they were dampened by their passage through the table materials. This meant that ordinarily harsh sound could actually be quite pleasant when reproduced through the table.

This was most evident with distortion from digitally clipping the audio signal. This created upper harmonics that if listened to as sound through a loudspeaker or headphones would be abrasive, but when played through the table, worked well to generate extra tones that made the sound more musical and harmonically rich.

This finding led to tests with using distortion plugins as a means of generating harmonics for a musical sound reproduced through the table.

I worked with harsh digital clipping in particular, as it offered a sudden increase in harmonics above a peak threshold. I was interested in this behaviour as it paralleled the way vibration sounds are made, when an object exceeds a movement threshold and starts to rattle. (See notes in Phase 1.2, Max/MSP research).

I also applied digital and other distortion in later tests such as the ‘March table project’ (Phase 5).
First time generating material intended for the table

Next I used a bass guitar to generate audio signal source material for reproduction through the table. See the section on abstraction of riddim (Phase 2.3) for the methods employed.

The harmonic structure from the guitar offered a deep, strong sensation augmented by other sensory information carried in the upper harmonics. This tonal structure provided a solid or ‘well rounded’ bodily engagement with the table.

This connection of low frequency sensation to high frequency sensation and hearing appeared to relate well to what I had found in my music sensation tests before the Masters program (see background). In these early tests with a vibration floor and loudspeakers, participants responded well when the frequency content of the bass in music was spread across the vibration and acoustic elements. Where these were not explicitly connected, with a large frequency gap between the low sensation and other elements, the vibration no longer added to the overall experience and could become disconcerting.

The use of the bass guitar also seemed to offer a ‘complete’ experience when physically engaging with the table, such as playing with hands on its surface or leaning against it. The upper elements tingled the skin, relating to touch with the hands and hand pressure, and the lower elements provided more of a full body engagement.

In previous research I had found that finger and whole body vibration are assessed separately in noise/engineering fields.¹ I had also found that some attributes of vibration perception have been assessed primarily or only in relation to finger vibration and skin effects, such as people distinguishing buzzing vs smooth vibrations depending on frequency.²

The experience of engaging with the table with both the hands and the upper body highlighted to me that while I came to the research with an interest in deep, whole body sensation with very low frequencies, it was important for me to consider the role of the hands and finger touch in engaging with the table surface. This included the need for composing with both low (30-50 Hz) and higher frequencies (80Hz+).

It also suggested that I may be able to offer a more compete audience experience by composing and installing for a reclining or sitting experience, touching the table surface with hands. I had initially envisaged a standing experience consistent with the nightclub and design research background I started from.

My later compositions (particularly undulation, Phase 6) and eventual approach to presentation (see presentation section) focused on a reclined audience interaction.

First experiments with table as a sounding device – larger scale vibrating material

During Phase 1, I struggled to abstract and de-reference actual basslines from music. In my tests with vibrating the table surface (Phase 2.1), I moved away from sampled music, and used a basic, three-tone synthesised pattern as source material. This approach helped me to explore vibration-relevant attributes of riddim without the direct musical link.

For example, I was able to explore the way changing tones activated different resonances in the table surface. Like with musical riddim played through a loudspeaker system and resonating a space, there was a definite activation and release of parts of the vibrating material, with each note carrying contrasting tonal and harmonic structures.

However, while this approach managed to avoid an overt reference to music, I found that the result was mechanical, without room for expression. I concluded that it was important for me to continue exploring shifting tones, but that I should use less rigid approaches to doing so.

This decision was partly because the switch in tones was too obvious when assessed as sensation. The experience failed to relate to my previous experiences of riddim sensation, where changes in tone and sensation effects were more abstracted and smoothed over. Considering my earlier testing, I knew this was partly due to the less clear/accurate way that low frequency sound travelled through a space, compared with vibration sent directly to the body.

First time generating material intended for the table

I set up a bass guitar with a small fan brushing against its strings to create a drone, and fed this signal into the table. This offered vibration sounds, while avoiding the issues of music reference and tone shifting. While not rhythmic, it provided a gradual organic variability that I couldn't achieve with the previous material.

I shaped the drones by taping contact microphones to the table and setting up a feedback loop, which modulated the signal. I then used a midi controller and hand pressure on the table and microphone surfaces to articulate the bass drone and feedback.

This provided pleasant deep drone sounds that ventured into more chaotic modulation feedback. Despite unpredictability and lack of fine control, the results suggested the possibilities of using slowly shifting patterns, feedback and modulation to hint at the tonal effects of riddim.
1 = Bass guitar ‘played’, various drones, plucks, strikes and detuning. Signal from guitar fed into computer

2 = Audio signal from guitar fed from computer, through amplifier, into the table

2a = the table generates vibration energy (a ‘vibration reproduction’ of the audio signal)

3 = a contact microphone used to pick up the vibration on the surface. Creates to the feedback loop, controlled separately

4 = The “audio signals” are recorded onto the computer, to be played back into the table in future, used for composition

Overview of bass guitar and tactile feedback tests
I presented a movie to the RMIT Sound and Media Arts postgraduate students, showing the experiments with tactile transducer feedback (see riddim, Phase 2.3) and vibration with small objects (see materials, Phase 2.1).

We discussed whether the research was intended for performance or installation, as I was not yet certain of the outcomes.

While talking about making the sounds, I reflected that what was most interesting to me was not the sounds made, but the tactile experience of generating them. This discussion helped me to resolve that the research would focus on installation using the table, as this was the only way to offer my exploration of vibration sensation to an audience.

We also discussed how a vibration-based approach might differ from works in the field such as the low-frequency sound performances of Randy Yau and Scott Arford. I highlighted distinctions such as a vibration installation offering an internalised sensation-based experience, as opposed to performance using sound to explore architecture and the role of the body within a space.

The conversation also helped evolve my approach to a ‘method of improvisation’ for creating the audible elements of my work.

We discussed how making sound with drones and feedback offered interactivity and playability, but presented considerable uncertainty in the way the table surface would feedback.

The group queried how I might deal with this unpredictability in composition and suggested that I define simple and predictable parameters to work within.

I brought this thinking to my next work gutterglass, where I used guitar drone recordings as a stable reference point, and techniques such as hand dampening and releasing of the sound-making materials to deviate from this.

Following the discussion I thought about what I could do to further my research. I had already explored ideas around:

- musical dissociation, and filtering / distortion to blur between vibration and tone
- parameters such as frequency range and amplitude and how this affected table sound/vibration
- riddim and its tension, potential and limitations
- range of playability, (a sense of learning instrumentation/techniques)

What was next? This thinking led to my work under Phase 3.
Phase 3

Playing the table, exploring sound-sensation interactions

August 07 – November 07
I furthered my experiments with deep bass guitar drones and tactile transducer feedback. I focused on what would work as vibration sensations, rather than as sound generated through the table.

I recognised that there were inevitably some audible sounds generated by the table, and developed ambiences to work with these sounds, to complete the vibro-acoustic experience.

Next, I used the table to resonate building materials such as windowpanes and sheet metal. This provided a new palette of sounds to work with the sensation experience. The materials offered new approaches to playability and expression when making vibration sound.

A first complete composition gutterglass (Phase 3.4) embodied this research. It helped me understand how sensation, when combined with sound, affects auditory perception, and how vibration could work in a vibro-acoustic narrative.

Overview of research outcomes

I explored the following principal research aims:

- 3.1 - Tactile system as an instrument - composing for the body, and generating sound
- 3.2 - The dialogue between hearing and sensation - felt and audible aspects affecting awareness and perception of each other
- 3.3 - Low frequency sound activating spaces - articulating building materials through vibration

The research and composition process set the building blocks for the rest of the masters program, on how the senses interact, the sorts of sounds I could create with building materials, and the sort of vibration territory that worked most naturally.
I addressed a unique compositional challenge bought about from making vibro-acoustic work.

I worked with vibration and sound, but sometimes couldn’t experience these together. I had to imagine the role one sense would play, while working on the other element of the work. I developed a software interface to make this process more intuitive, and reflected on how this challenge defined the approach I took to composition.

This package of work formed a foundation for the rest of my research, as it asked questions around the role vibration might play within the narrative of a vibro-acoustic work, and whether the acoustic or vibration element should ‘lead’ the structuring of a composition.

Other outcomes were predominately about strengthening and applying my earlier findings in creation of a work, and focusing on compositional approaches that seemed most successful for both sensation and hearing.
## Phase 3

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| **Composition gutterglass embodying research** | First thoughts/ application about how sensation can act within the narrative of a work  
Applying idea of ‘method of improvisation’  
Understanding how sensation affects perception of sound  
Developing methods for composing sensation and sound elements | **Abstraction of ‘riddim’**  
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Developing a narrative for the role of the vibration element within sound – to support, enhance a sound, then moving to prominence within the larger piece  
The experience of sensation ‘mutes’ the sensitivity to otherwise potentially harsh sound – sound experience highly altered by sensation |

Research provided the building blocks for the rest of the Masters program, on how the senses interact, the sorts of sounds I could create with building materials, and the sort of vibration territory that worked most naturally.

Outcomes started to tie in most comprehensively to the four research aims.
Following the three-tone rhythm and tactile feedback tests (Phase 2) and discussions with the Sound and Media Arts postgraduate students, I thought about:

- how to compose material for sensation, to extend beyond my mostly sound-based approach to date
- challenges such as unpredictability when using tactile feedback
- issues of expression and playability with tactile feedback
- my desire for a framework for improvisation for making sound through the table

As a tangible project to address these issues, I processed and arranged some crafted bass drones for a sensation composition.

I highly detuned the bass guitar (very loose strings) and placed it onto the table. The signal from the guitar which was fed into the table, creating a tactile feedback favouring the resonant frequencies of the guitar strings. The results provided:

- passages of very deep and sensorially interesting vibration
- a way to focus on the sensation experience rather than sound
- an organic variation in level, but within an appropriately limited dynamic range that minimised unwanted noise from the table

(as identified as an issue in Phase 2.2)

- scope to articulate and express beyond the central sound, via additional layers of tactile feedback and haptic interaction
- an ebb and flow to the sensation level and frequency that alluded to musical riddim. The additional modulation through feedback also gave a sequence-like patterning, which provided a further (abstracted) connection to riddim.

This provided a framework for the tactile component of the work gutterglass, and was also a springboard for the next steps of making sound.
1 = Bass guitar ‘played’, various drones, plucks, strikes and detuning. Signal from guitar fed into computer

2 = Audio signal from guitar fed from computer, through amplifier, into the table

2a = the table generates vibration energy (a ‘vibration reproduction’ of the audio signal)

2b = vibration feedback loop generated through the guitar, exciting different responses from the guitar

3 = a contact microphone used to pick up the vibration on the surface. Microphone contributes to the feedback loop, controlled separately

4 = the vibration through the floor is picked up by a record needle. A feedback loop explored separately from the guitar

5 = The ‘audio signals’ are recorded onto the computer, to be played back into the table in future, used for composition

Other source material fed via computer includes synthesizers, and processing of the audio signal, including pitch lowering, also executed in real time

Overview of how vibration is used in sensation composition
Phase 3 - Hearing and Sensation

The bass guitar feedback drones (Phase 3.1) provided a successful sensation experience. However, for a person lying on the table to experience the sensation, the table made a significant amount of noise that was not particularly interesting or engaging.

To complement the drone-based sensation and this sound, I explored sound generated by means other than the table.

From my background research and my own tests (see background), I knew that listeners could be distracted when sound and vibration weren’t in time with each other.

Partly because of this, I focused on separating the audio signal used for the vibration and separately processing it to create accompanying loudspeaker-reproduced material. Using the same audio source, combined with the long envelope nature of the drone material, helped to make timing less of an issue.

I made the sound spacious and ambient, and accentuated harmonics that would connect well to the tones heard through the floor. This helped to create a summed experience. It also avoided the issue of a large frequency gap between the vibration and sound, which I knew from my early music tests could create a disconnect between these elements.

The work was largely done in Max/MSP, in a patch I designed to allow for the processing of multiple streams of sound from the original drones, in a way that facilitated layering and feedback.

**Vibration and manipulation of large scale building materials**

Next I created vibration sound from large scale building materials, and applied this together with the computer processed ambiences (see Phase 3.3 on the approach to crafting sound from the materials).

These experiments were also firmly about the interaction of the sound with sensation, and a focus on making sounds that complemented sensation as the central element to the work.

**Gutterglass - role of vibration**

_Gutterglass_ developed from the above tests with building body vibration and making complementary sounds.

As I began to make and arrange the recordings in a longer sequence, a new challenge emerged on how to place sensation within a vibro-acoustic composition.

While I aimed to develop the composition around the vibration element, most of my working process was on the interactions between
the audible aspects. When mixing the computer generated ambiences with the vibrating materials recordings, it was too difficult to assess the vibration at the same time.

Also, when creating the sound from vibrating materials, I was unable to experience the sensation component, and had to guess its placement relative to the sound.

The sound ended up ‘crowding out’ my perceptual faculties when structuring the work. I wasn’t able to place the emphasis I wanted on the sensation track, and it ended up being revisited as a supporting element to the sound tracks.

The final composition had the vibration track running alongside one part of the audible arrangement (that of a discordant rattling window). The vibration followed an arc of increasing amplitude, and then decay. It moved from supporting and enhancing the experience of the sound, to prominence and demanding more direct sensory attention.

This linked thematically to the approach taken to each of the audible elements (see Phase 3.3), and helped me express the perceptual continuum that vibration sits within.

The challenges around placing the vibration within a mix also raised broader questions about how effective and communicative vibration could be. I asked:

Will vibration always be perceived as an adjunct to sound, where sound is present? Is it inevitably a ‘lesser sense’, in that it doesn't provide as much critical information in a routine perceptual or evolutionary capacity? To what extent can a composition be based on and driven by sensation?...

I explored these ideas in later compositions.

Vibration and sound perception

The deep drone in gutterglass had a disengaging or lulling quality. The sensation was almost a sort of massage, encouraging shutting off of critical thought or analysis of the sensation and accompanying sound. This seemed to be consistent with the kind of results offered by vibro-acoustic therapy, which also tends to use sensation drones.²

Gutterglass involved some fairly harsh sounds from the vibrating building elements. The relaxing or somnambulant properties of the sensation seemed to dampen the listener’s sensitivity to this. In my early music/vibration tests, I found that vibration reduced sensitivity to sound level. Gutterglass showed that this might extend to perception of sound character as well.

Some listeners found the sound in gutterglass highly suggestive of vibration sensation, leading them to believe there was sensation even when not present. This worked with my deliberate intent to only use the vibration within the climatic phase of the composition. I continued to take advantage of this psychoacoustic effect in later compositions.

Intensity peaks in the sound also increased the perceived vibration intensity for some listeners and for myself when listening. The strength and consistency of this effect was not entirely clear. However, it appeared to conform to Altinsoy’s findings on combined acoustic and tactile-force stimulus, where increased sound level resulted in a perceived increase in sensation feedback to the hand³.

1. Martens, 2005
2. Hooper, 2002
3. Altinsoy, 2003
Vibration and manipulation of large scale building materials

After the work with vibration and processed sound (see Phase 3.2), my focus moved back to the vibration of objects.

In my Phase 2 testing composition I included studio-based vibrations from small objects (glasses, coins etc. on the table).

This offered a ‘live’ sound that made the composition more immediate and connected it to the research interest in building vibrations. However, like with compositions by other artists using small vibrating objects (for example, Jeff Jerman, Untitled Sound Objects) the properties of the vibration sound didn't sufficiently allude to the nature of building vibration. For example, what is experienced in a nightclub or warehouse with loud dance music.

Conversely, my Phase 2 experience in ‘playing’ the table MDF to create sound offered a unique sense of control and engagement with a large piece of construction material, but presented quite one-dimensional sound.

As a convergence of these experiments, it struck me that now I had a large, manipulable instrument that I could ‘play’, and that perhaps it could be applied to large real-world building materials placed on the table.

I went to a wrecker and picked dilapidated and likely-to-rattle materials: two windowpanes with much of the perimeter seals missing, metal sheeting and tiles.

I experimented with placing these on the table and creating sounds to go with the processed sound textures.

This offered something substantially new. I had the large-scale tactile playability that I enjoyed with just the loose table, but with greater sonic range and freedom of expression through hand dampening and arrangement of materials. For example, I experimented with propping the window panes at different angles to change their resonances, layered the tiles on top of each other to change the rattles, and used finger pressure on key points on the glass and guttering to change the profile of sounds.

Phase 3 provided substantial developments in the approach I took to making sound, as I moved to using large-scale building materials and explored the range of sounds they could make.
In particular, I focused on the finger pressure and release on the glass, across different points on the surface, and how this could subtly change the profile of the sound. Containing the resonance through dampening also helped to express the sound as an edge or augmentation of the other computer processed textures, rather than a continuous rattle.

The computer processed textures provided a backdrop and reference point for making these sounds. They also filled the sonic and timbral gaps of the building material vibrations.

The building material sounds were on the whole abrasive and bold in character. They were mid-to-low frequency in nature, not having any real high frequency content or ‘sizzle’. The computer processed textures provided high frequency content and a smooth, softer backdrop.

Developing software framework for vibro-acoustic composition

I developed a multi-channel Max/MSP setup to enable a more intuitive and responsive approach to playing the table and objects. This was essential to creating the work *gutterglass*.

In *gutterglass*, once building an initial sound (from guttering), each aspect of the piece was made by listening to the preceding ambient and pre-recorded elements through headphones, as well as the computer processed drone material. The sounds captured by the microphones were also fed to headphones so I could understand their interaction (see illustration overleaf).
1) The table used to vibrate a material (e.g. window pane) into resonance. Materials also 'played'/dampened by hand and the sound recorded (r).

2) Recordings from 1) listened to via headphones, guiding next, and subsequent recordings (r) made from other materials (x) on the table.

Final piece made from selection, layering and processing of the building material recordings.

Experienced via loudspeakers, whilst engaging with the sensation of the table. This sensation has the same origins as the vibration used to make the sonic material.

Overview of stages for making a vibro-acoustic work
Gutterglass - approach to materials

To make the audio parts of gutterglass, I set out to cover the full sonic range available from the materials, from quiet and ambient, to distorted, rattly and discordant.

I was guided by James Tenney’s Koan: Having Never Written A Note For Percussion. Koan sets up a gradual crescendo for a percussion instrument, exploring how with repeated, equally timed strikes of increasing intensity, the instrument’s resonances and colour will change.

The audio element of gutterglass combines three building material recordings (guttering and two different windows) that individually follow a similar trajectory. All were activated into vibration by the same pattern through the table, which followed a gentle rise and decay over several minutes. The final arrangement of these recordings also traces the same general pattern.

With two of the recordings, I used my finger pressure and release to accentuate this rise and decay, by gently reducing the amount of dampening on the surface over the course of the recording.

I found this was necessary as without some control over the vibration, the materials could make very dominant or harsh vibrations with only very little vibration stimulus.

Microphone findings

When making gutterglass, I experimented with a range of microphone placements, using microphone pairs, generally elevated away from the vibrating surface.

This highlighted the complexity of the sounds, and limitations to what I could capture without very good microphones and precise placement. Although sounds like vibrating glass were very immediate and ‘sharp’ in person, it seemed almost impossible to capture this, particularly in the high frequencies.
Phase 4

Developing content for the table and the body

November 07 - October 08
I developed a second composition that combined sensation and hearing, and attempted to provide more space for improvisation and gesture when making sensation. This presented new challenges around how different frequencies and intensities of low frequency signals would interact when presented as sensation.

When interacting multiple vibration tones, I experienced phase interference / cancellation issues (modulations and collapse of the vibration signal). These suggested tight limitations on building sensation composition. I developed further experiments and a working methodology from this finding. A composition made for sensation without sound helped to solidify and apply my findings.

The work also helped me to set logical boundaries when placing compositions within the spectrum between symbiotic or ‘contrapuntal’ interaction between the acoustic and tactile elements.

**Overview of research outcomes**

This period explored all of my principal research aims:

- **4.1** - Low frequency sound activating spaces - articulating building materials through vibration
- **4.2** - The dialogue between hearing and sensation - felt and audible aspects affecting awareness and perception of each other
- **4.3** - Tactile system as an instrument - composing for the body, and generating sound
- **4.4** - Abstraction of “riddim” – basslines moving from musical to environmental

A main finding was that texture was integral to how vibration engages with the body, over tone, frequency or other aspects of timbre.

I also identified and began to address conceptual challenges about using vibration as a medium to express and communicate.

At the end of this phase I found a comfortable and successful range of approaches to sensation composition, based on a more developed understanding of sensation perception.
### Phase 4

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**Note:** The table above outlines the findings against principal research aims, focusing on key directions such as the abstraction of 'riddim,' low frequency sound activating spaces, and the tactile system as an instrument. It also highlights the dialogue between hearing and sensation, revisiting sensation from riddim in various contexts like composition and reflecting on fundamental limitations and boundaries to vibration experience.
### Time/Work

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**Work “bass feedback July 08”** – based solely on tactile experience

Use underpinning very low frequencies

Focus away from comfortable drones to something encouraging thought on sensation

Breaking down elements of sensation opened up my understanding and work through concerns with the limitations of the medium.
My Phase 4 findings on articulating building materials were mainly about making my approach to sound-creation more expressive and improvised.

Testing through composition also helped explore the resonant ‘sweet spot’ of materials and the timbral range of vibrating glass/windows and metal.

**Composition ‘Sines 121 Hz’ exploring sensation construction**

I made this testing composition at the same time as *gutterglass*.

I placed old corrugated iron on the table and applied a 121 Hz sine tone vibration to it, tuned to achieve a strongest resonance from the iron.

I experimented with changing the level of vibration and with hand dampening, to further articulate its sonic range. I also applied harmonically related lower tones, fed underneath the 121Hz tone, to achieve more ‘wobble’ and ‘flutter’ in the vibration signal.

When activating and dampening materials to craft the sound, I aimed to provide a sense of ‘containment’ to the vibration sound. This was to suggest that there is this vibration potential in any material, which can be revealed with sufficient low frequency stimulation.

Whilst listening back to an iron sheet recording, I followed the same steps with a window pane, to work with the prerecorded track.

When making the work, I focused on ‘bold’ interactions between each track, to provide more space for free gesture and dynamic response, compared to the more carefully structured *gutterglass*.

I also tried to reveal the more brittle and bright properties of the glass, to suit the dramatic approach in the work and to expand the tonal range I could work with.

I used a range of near and far microphone techniques, and applied very intense vibration with only loose dampening of the materials, to emphasise higher frequencies and harsher tones.

However, it emerged through the recording process that the presence and intensity heard in the room was still not being well captured, even with these approaches.

It also became apparent that the glass itself didn’t provide much high frequency energy (i.e. above 14kHz) and most of the energy was under 2KHz. This appeared to be due to its resonant properties and the lower frequency signal driving it. These limitations in expression and sonic presence led me to consider greater use of digital signal processing.

Later works (see Phase 5, ‘March table project’) applied effects to amplify or reproduce the vibration characteristics that were most striking in a natural / real-world context.
Phase 4 - Hearing and Sensation

Phase 4 tests helped me to set logical boundaries when placing compositions within the spectrum between symbiotic or 'contrapuntal' interaction between the auditory and tactile senses.

Composition ‘Sines 121 Hz’

In *gutterglass*, I set up a logical and comfortable interaction between the tactile and acoustic elements, where the sensation matched the sound in timing and intensity.

*Sines 121 Hz*’s arrangement was less synchronised. More intense passages of vibration roughly followed the timing of intense sounds, but with occasional and variable timing differences such as a slight delay in onset. I also set up variations in the form and intensity of vibration that did not directly respond to sound.

This approach was taken to:
- ensure I didn’t limit myself to what was initially appealing, but obvious
- cover less explored territory. I understood that vibro-acoustic therapy tended to use aligned sensation and sound to provide a relaxing effect.\(^1\) Interfering with this alignment offered potential for different types of experience.
- respond to my own perception of vibration. With extended listening, I became ‘densensitised’ to the overall relaxation/disengagement effect of the vibration experience, and started to focus on the subtleties of presentation and sound/vibration interaction
- test how participants would relate to the work when the senses were not matching each other all the time
- allow me to follow passages of vibration that were effective for the body, without being bound to how this matched the sound (see Phase 4.3)

Consistent with the rest of the composition, the counterpoint between hearing and sensation was coarse and dramatic.

Feedback from my supervisor and others suggested that the disconnect between the senses was too much. People commented that they expected a synchronised relationship between the elements. By going against this, the piece felt ‘illogical’ and distracting.

The comments suggested that future tests on divergent sound and vibration would need to be carefully framed. I continued to explore this theme in later works, but with more subtle timing offsets, and limited to particular patterns of vibration (see *undulation* Phase 6).

1. Hooper, 2002
Composition ‘Sines 121 Hz’ exploring sensation construction

I started the sensation element of this work with a 121 Hz sine tone, fed through the table to loosely follow the envelope of a segment of the acoustic track (see Phase 4.2 on the sound/sensation dialogue).

This frequency was physically engaging but also forceful for the head when lying on the table. The vibrations appeared to travel very efficiently through the skull, with effects on vision.

I focused on how I could make more engaging and comfortable sensation effects, based around the 121 Hz tone and a loose correlation with the sound component.

I tested a selection of harmonically related undertones. These expanded the range of sensations I could present, including more whole-body sensation. They also partly neutralised the strong head sensations from the 121 Hz tone.

I applied these deeper tones to accentuate, through sensation, the more dramatic moments in the sound. As with the creation of sounds, I focused on loose gesture and improvised expression.

However, I found that I couldn't just ‘push’ energy into the table by driving different tones. The different vibration waves strongly phase cancelled and modulated each other.

The resulting sensations sometimes totally diverged from what I was hoping to express at that moment. The interactions were unpredictable, varying significantly with the different levels of tones and slight frequency differences.

There did not appear to be the same latitude for phase interference as there is with loudspeakers and sound, as the vibrations were focused on a single point source and surface area, unlike soundwaves varying across a listening room/space.

Consequently, I decided to focus on building up sensation tones more slowly, through repeated listening and track automation, rather than through real time gestures and improvisation.
Another finding was that very low-level, low-frequency tones could be used underneath an existing tone, and that these could alter the feel of the tone, adding a deeper texture to the sensation without abrupt phase interference.

Both of these findings were applied in my approach to later works.

**Reflecting on fundamental limitations of and boundaries to the vibration experience**

Making gutterglass and sines 121 Hz highlighted how coarse the vibration medium was compared to sound.

I had to deal with the limited dynamic range of sensation, because the vibration actuator didn't work well at low levels, and because of limited perceptual sensitivity/range compared to sound.

The challenges when making sines 121 Hz also suggested that vibrations needed to be simple in order to be clear.

My experiences suggested that fundamentally, our perception of vibration is one-dimensional. Vibration appeared not to carry the same capacity for emotional/intellectual significance as sound.

These technical concerns led me to consider broader issues about what could be ‘expressed’ through vibration without a supporting or leading sound. I asked:

*Can vibration be expressive or emotionally communicative? Does it need to accompany sound to carry such intent?*

*What do these limitations mean for my research aim of exploring the medium of vibration? For the vibration to be expressive/communicative does it need to form part of sound? To date, my tests with vibration by itself didn't seem to provide content that made aesthetic sense to the listener...*
Content creation for sensation, without sonic relationships

My concerns about the limitations of vibration for communication and expression led to a series of tests. I focused on what is engaging and interesting to the body, without need for supporting sound.

I started by testing which frequencies activated the table or the body in interesting ways. I swept sine and saw tones through the table (15 to 150 Hz). I noted the tones that provided a strong sensation effect (for example, 23 Hz, 25.5 Hz).

While this material was simplistic and mechanical, it was useful to understand that single, simple tones could be interesting as vibration, and that each tone had a distinct sensation character. In later works, I often drew from this bank of tones, to support other vibration elements in the composition. Next I experimented with turntable feedback.

I put a turntable needle on the outer rim of a still record. The very low frequency resonance of the turntable pickup/tonearm became an amplified electronic signal. This signal was sent to the vibration table.

The vibrations through the table were sent from its frame and legs, into the floorboards in the studio space and back to the turntable. A hit to the vibration table could set the feedback cycle off.

I made an interesting range of vibration states by standing, lying, and pushing on the table in different ways and locations across its surface. Depending on how the table was grounded to the floorboards, I could make modulations, stutters or drones from the feedback.

Similar to my early tests with the loose table top (see Phase 2), it was very engaging to actively play the table with my body.

I edited the turntable feedback recording into segments, based on the pattern of the vibration, such as how the vibration ‘fluttered’ or ‘throbbed.’

Paralleling the earlier sine-tone tests, I pitch shifted these segments until I found a ‘sweet spot’ where they were most physically engaging.

This experiment significantly developed my understanding of sensation.

My approach to the vibration sensations was about their texture, rather than tone or timbre. I thought about characteristics such as roughness or shakiness, rather than pitch or harmonics.

Often, I drew comparisons to real world experiences of vibration texture, such as driving a car over the edgeline of a road, or touching a panel on a motor casing.

This development was significant to how I approached all future sensation compositions.
1 = Bass guitar ‘played’, various drones, plucks, strikes and detuning. Signal from guitar fed into computer

2 = Audio signal from guitar fed from computer, through amplifier, into the table

2a = the table generates vibration energy (a ‘vibration reproduction’ of the audio signal)

2b = vibration ‘feedback loop’ generated through the guitar, exciting different responses from the guitar

3 = a contact microphone used to pick up the vibration on the surface. Microphone contributes to the feedback loop, controlled separately

4 = the vibration through the floor is picked up by a record needle. A feedback loop explored separately from the guitar

5 = The ‘audio signals’ are recorded onto the computer, to be played back into the table in future, used for composition

Other source material fed via computer includes synthesizers, and processing of the audio signal, including pitch lowering, also executed in real time

Overview of how vibration is used in sensation composition
Work “bass feedback July 08” – based solely on tactile experience

Between July and October 2008 I developed a work focused only on sensation, without an audio component.

This incorporated elements and findings from:

- the sines 121Hz work on constructing vibration from underpinning deep tones
- earlier experiments with bass guitar feedback
- returning to other (non-drone/feedback) results from the guitar tests, and focusing on plucked strings and impulsive elements
- the turntable feedback
- using substantial detuning/pitch shifting to find sensation ‘sweetspots’
- the shortcomings and successes of the concurrently conducted audio-tactile composition (see Phase 5), where I tried to avoid working with just drones and modulations

The composition was evocative of faulty equipment or electrical shorting. It incorporated short, jolting bass guitar plucks, with deep sines interacting at low levels, and a slightly ebbing passage.

The work was deliberately not comfortable, but stimulating and focus-grabbing from just a sensation perspective.
Dedicated work on abstracted riddim as a sensation

The following research was separate from the sines work and sensation-only composition.

I had previously tried a range of techniques to blur and obfuscate the sound of music basslines, to make work that subtly referenced riddim without an obvious musical link. I found that this was difficult to achieve and that any residual rhythm would grab a listener's attention.

During Phase 4, I applied similar techniques to blur the vibration from music basslines, as represented through the vibration table.

I sampled and edited small bassline loops, primarily from dubstep tracks with a suitable frequency concentration at below 60Hz. I used reverbs and delays to smooth the sample into a more constant sensation.

It was difficult to avoid the overt musical reference in the vibrations. However, with some material and processes, I was able to set up a softer undulation between notes, without strong rhythmic punctuation.

This seemed to capture an essence of the basslines in a new way, and highlighted the continued relevance in drawing from riddim.

Unlike the results from the recently applied drone material, this music-based approach provided a sense of 'grip' and 'release' to the body that shifted with different notes. Even when smoothed out and more gradual, this transition between notes seemed important to maintain.

This finding guided later thinking on how undulating low frequencies could create an effect similar to riddim.

I was also reminded that the shifting tones offered different acoustic effects to those from drone vibration.

Materials in the studio and parts the table surface were activated by specific notes. The effect was similar to the 'real world' way that heard vibration in building materials can come from passing low frequency sounds, like a form of 'delay' from the room, triggered for a short moment in response to a bass note.

This reaffirmed the importance of continuing to consider riddim-based vibration, despite the recent successes of drone-based material.
Phase 5

New approaches to sensory interaction and vibration sound

March 08 - July 08
I made a new work ‘March table project’ with different vibrating materials, greater layering of sounds, and different vibration effects. I approached the compositional narrative in a new way, leading from vibration rather than sound.

I presented the acoustic component of the work to Berlin based sound curator Elke Moltrecht. Feedback from her and others highlighted the shortcomings and lessons from the composition, and validated my intended approach for installing vibration with sound.

**Overview of research outcomes**

This period explored the following principal research aims:

- 5.1 - The dialogue between hearing and sensation - felt and audible aspects affecting awareness and perception of each other
- 5.2 - Low frequency sound activating spaces - articulating building materials through vibration

The main development was in my understanding of how perception shifts focus depending on the makeup of the sound and sensation elements in a composition.

I started by focusing on engaging sensation components/phrases. However, when I introduced sound into the composition it ‘sidelined’ the amount of engagement or focus a listener could have on the sensation experience. The audible sense took primacy, even where the content was meant to support the sensation experience.

This had an important bearing on my approach to structuring compositions. It was also challenging when moving back and forward from sensation generation to audible vibration generation, as these both couldn’t always be experienced at once.

I thought about the narrative arc that I wanted to employ. With gutterglass, I found a comfortable area based on drones and closely aligned, simple passages of sound and sensation. In the ‘March table project’, I aimed for smaller phrases of sensation such as stutters and pulses, and more complex sound/sensation interactions. I tried to avoid staying within the comfort zone of the earlier work, and to establish a greater the range of inter-sensory experiences.

I also worked with new sound-making materials including wires and metal sheeting, made harsh and discordant vibration sounds, and layered many sonic elements together.

**Phase 5 - Summary**

During this phase I resolved some of the challenges raised during earlier compositions, primarily concerning the dialogue between the senses.

I investigated the ways perceptual focus can shift depending on the way sound and sensation are presented. This included developing my process for composing sound with sensation. I also expanded the sonic palette I was working with from vibrating materials.

I moved outside the compositional comfort zone established in earlier work.
I found that I needed to limit the complexity and layering of sounds given their (in)harmonic makeup, and that I didn’t need to reach full discordant vibration from materials. I also improved my understanding of microphone technique and eq’ing.
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| Element 1 of composition  
'March table project'  
– building from vibration | Structuring a longer composition around passages of engaging vibration  
Moving away from comfort zone, avoiding easier approach of lulling drones | Mixture of vibration effects, broken up and not following smooth drone type passage, aiming for more complex compositional arc  
Using material from range of previous tests, guitar feedback, turntable feedback, plucks, stutters, sines – all based on engaging texture | Aim to have sound build on vibration experience, rather than vibration enhancing the acoustic information |
| Element 2  
– building layers of sound | Tension develops  
– vibration becomes subordinate to sound, and vibration narrative gets lost with accompanying sound  
Pushing my understanding of inter-sensory dialogue | Building layers of sound, flattens the perceived timing, decays, and articulation of the vibration  
Rearrange to enable sound lead  
Build other passages without vibration element, or more subtle underpinning vibration |
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<td>Element 3 – expanding range of materials</td>
<td>Opening up frequency range, colour of sounds, mic technique</td>
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<td></td>
<td>Aiming for harsh and subtle sounds</td>
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<td>Working on intersection of many different vibrating materials recordings</td>
<td>Tactile system as an instrument</td>
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<tr>
<td></td>
<td>Using greater range of materials – wires, glass objects on metal</td>
<td>The dialogue between hearing and sensation</td>
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<tr>
<td></td>
<td>Close miking technique</td>
<td></td>
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<tr>
<td></td>
<td>Many layers of sound, aiming for greater complexity</td>
<td></td>
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<tr>
<td></td>
<td>Inharmonic clashes, try to craft around using more eq, fx</td>
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Excellent research process, but end result overlaboured and not successful artistically. Pushed from my comfort zone in how to structure work, tested boundaries in how the senses interacted, approached the compositional narrative in a new way, and learnt much about selecting, miking and arranging materials.

Most useful were understanding limitations which guided later work, on limiting the complexity of sounds given their (in)harmonic makeup, on not needing to reach full discordant vibration from materials, on the advantages in drones, modulations, on not becoming lost in tweaking recordings. Also significant gains in my understanding of microphone technique and eq’ing.
In *gutterglass*, I created a structure largely suggested by sound, and interwove the vibration into this.

For the ‘March table project’, I started from the building blocks of what makes interesting sensation. I used material from the earlier experiments (sines, saws, turntable and bass guitar feedback), and arranged these into a passage that by itself was physically engaging and possessed a sense of internal logic.

I avoided using one lulling oscillation or drone, and applied a range of rattles, shakes, stutters, explosions, and undulations, based on textures that were interesting to the body.

I built the sound around this by placing materials on the table and causing them to resonate in response to the same vibration passage. I made multiple recordings, and then listened to layerings of these with the sensation.

Soon a challenging friction developed, as what made sense for the body became subordinate to the heard content. Vibration structures that worked in isolation lost their internal logic when the sound was present, and the vibration was no longer as engaging.

Also, the decays, timing and articulation of the sounds wasn’t ideal, because they were made according to the vibration compositional arc.

In response, I edited and rearranged the material, to maintain, on a micro level, the sensations that worked, but create a macro structure that was led by the sound.

From this rearrangement, I created and inserted other passages of sound to make the macro structure work better. Not all of these contained a vibration element in support.

These steps developed my understanding of the vibration/sound dialogue and the overall possible role of vibration within a composition’s structure/progression.

During Phase 5 I concentrated on the way perception focuses on sound over sensation, and what this means for composition.
My previous works involved an interaction between one or two different recorded materials (such as windows and sheet metal) plus other ambiences or effects.

In the ‘March table project’ I focused on new sounds and textures that occupied a higher frequency register. I also used smaller elements and features in addition to the larger vibrating materials. These included wires on metal, thin aluminium, and glasses and bolts on metal and glass.

I applied less hand dampening and releasing than with earlier works, focusing instead on the miking approach.

I used very close miking techniques (a few mm away from the surface) to highlight particular buzzes and resonances from the materials that were specific to points on the surface. I also recorded at locations close to the surface where multiple strong vibration points (anti-nodes) could be heard interacting.

To make a more complex work, I made many recordings, with up to 15-20 to draw from for any one passage.

This layering process presented a new challenge. The resonating materials were largely inharmonic, and the structures of their overtones don't follow
neat or even structures. Consequently, with layering, it was difficult to find overlaps that married well, particularly when using different types of materials together.

I spent a considerable amount of time eq’ing and applying effects to narrow or strip down to the essence of each sampled sound, to maximise the potential for using sounds alongside each other.

While the end result was over-processed and dense, these steps helped me to understand the nature of vibration sounds and how to best reveal and inter-relate them.
Phase 6

Riddim exploration to a focal point, settling expressive range

August - November 08
This phase marks a conclusive point in my research. Through research and a composition, I found an effective domain for creating sound and vibration.

I addressed questions about sound from building materials, the abstraction of riddim, and the dialogue between the senses.

The final approaches represent:
- settling of the palette I wish to work from, within the context of a defined field
- more developed approach to sound-sensation dialogue
- comprehensive understanding of how to use the table as an instrument

During this phase I applied more advanced approaches to vibration generation, including collaboration, real time pitch shifting and processing, and microphonic and tactile feedback to enable deep, textured and predictably manipulable vibrations.

I also worked with new materials, including an oil drum, as well as new microphone techniques. The composition *undulation* brought together the research findings and practice.

This period explored the following principal research aims:

- 6.1 - Abstraction of “riddim” – basslines moving from musical to environmental
- 6.2 - Low frequency sound activating spaces - articulating building materials through vibration
- The dialogue between hearing and sensation - felt and audible aspects affecting awareness and perception of each other

I reflected on approaches taken to the abstraction of riddim, from rhythmic/musical, to smudged riddim, to drones, to building sensation from basic components, to stutters and plosive sensation, and modulation.

I focused on slow passages of deep undulation as an effective point within this spectrum. This approach found the right balance in my aim to reference the qualities of musical riddim, without explicit reference to musical contexts. I intend to continue to use this approach within sensation composition.

I also reflected on the timbral range from materials that I had covered in the program, including large and small objects, and subtle to harsh sounds.

I found a comfortable point in my approach to exciting objects, whereby I could express the ‘potential’ for vibration energy in materials, through moderate and appropriately constrained resonance/vibration, without leading into full discordant vibration sound.

By Phase 6, the overall research program had answered my questions about the capacity of vibrating materials as a basis for composition. I found a flexible enough range of sounds to base a composition entirely on vibration sounds as a source material.

However, having reached this point, I recognised that I did not need to limit myself to this approach for all future work after the conclusion of the Masters.
I also settled on the approach to sound/sensation dialogue. During earlier research, I had experimented with entirely synched as opposed to ‘contrapuntal’ approaches. In the *undulation* composition, I maintained a general correlation between audible and vibration elements, with more subtle departures, or ‘easing apart,’ enabling a communicative link between the two senses.

The findings during this phase should be read in conjunction with the installation and presentation context section, which responds more specifically to thoughts associated with audience access and interaction with the work, in an installed context.
### Phase 6

#### Table overview

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**Active processing of detuned bass while in feedback**
- Developing further 'played' techniques for blurring modulation and drones
  - Real-time application of eq, pitch shifting, delays in the approach to bass guitar feedback generation
  - Microphone feedback on the table to best play at the fringe of feedback
  - Experiments with earth hum

**Collaboration: progressing ideas, move to undulation - tonal shifts, but organically smoothed and blurred**
- Strongest point in alluding to riddim without trappings of explicit musical reference
  - Engaging bass feedback around synthesised tones
  - More subtle sequenced step in tone pattern gave a nice sense of tonal shift without having a direct rhythmical reference
  - Feedback on this offered a sense of undulation, providing a building block for composition
- Expanding blurring approach to semi-rhythmical material, finding undulation and best expression
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| **Composition aims for containment of vibration sound** | Finding a suitable frame for expressing vibration sounds – referencing initial inspirations about all material having ‘potential’ for vibration energy to be expressed | Abstraction of ‘riddim’
- Found that I am comfortable not working with full range, harsh sounds
- Aim for sense of containment in the vibration, using hand dampening
- Expand range of materials – use steel drum, new miking approach |
| **Pushing at fringes of sound / tactile interaction** | For vibro-acoustic structure, following from closely correlated, to against each other, to independent vibration, settling on closely matched with more subtle departures | Low frequency sound activating spaces
- Structure aims to maintain a general correlation between hearing and sound, but with some more subtle moments of departure, where elements support each other but don’t strongly contrast |
| **Group feedback, thinking about installation context** | Again suggesting ways to best frame composition and how it is presented - considering installation context ‘attention span’ | Tactile system as an instrument
- Consider how more subtle elements communicate in installation, and how to best frame the experience |

End point: finding a comfortable and effective frame for composition, which addresses my research questions. Provides basis for ongoing work with vibration, and future investigation of installation approaches.
This period involved significant experimentation with generating vibration sensation source material, with a particular focus on processing bass guitar feedback to trigger an ebb-and-flow effect in the sensation. As before, I tried to keep the link to riddim that had motivated earlier work. I had sufficiently mapped the territory to suggest what worked most successfully. I:

- started from recordings of musical bass
- filtered basslines and recorded their effect on a space
- 'smudged' and processed basslines to get a sort of rhythmic effect on the body, when fed into the table, but it was too overtly musical
- worked on raw sine and saw waves and used flanging and phasing to step and shift the tones, but decided that it wasn't organic nor subtle enough
- had success with drones. However, these didn’t capture the essence of riddim, such as shifting patterns with frequency changes. These elements were necessary to draw on the sense of vibration gripping the body in different ways with different tones, in a riddim-like way
- applied short passages of stuttering, more plosive vibrations, which were engaging but on a different tangent from the riddim basis. They did not offer sensory deactivation, or relaxation (components that I considered essential in the experience of musical riddim)
- plucked, detuned and rested the bass guitar on the table to generate modulated feedbacks. However, this modulation was strong and ‘punctuated,’ with a short envelope, leading to a vigorous sensation effect that was not seductive
- knew interactions of recordings or tones could yield interesting phase interference effects, which, when subtly applied, helped to give body and texture to the sensation
- had success with pitch shifting material downwards to hit the sensation ‘sweeps’

Considering these aspects of the research, I recognised that I had followed a trajectory from rhythm, to drone, to modulation. I had touched upon and was motivated to further explore undulation of bass material.

For this research, undulation could be understood as material offering subtle and slow movement in tones and pattern, but without the explicit musical reference to rhythm. Alternatively, where the sounds/sensations would gently move into and almost out from deep, strong tones.

I developed a number of tests to further my application of bass undulation, particularly for sensation.

The results of these were employed in the undulation composition.
Revisiting detuned bass resting on the table, to work around the edge of feedback

With the bass guitar signal sent to the table, I rested it on the table with highly detuned strings.

I experimented with real-time pitch shifting and signal processing of the guitar signal. Processing included signal compression, low pass filters and tape delays.

This approach built on what I had applied on pre-recorded segments. However, processing the sound as it was made offered more dynamic and intuitive control of the vibration effect.

The combination of effects offered a generally gentle undulating and textured signal without the strong modulation I had previously experienced.

Building on this, I used a microphone to pick up the sounds from the table or guitar itself. Like the guitar, this signal was fed into the table using similar signal processing, particularly strong downwards pitch shifting.

This was very successful. Placing the microphone at different distances helped me to play with the threshold of the point of feedback, and manipulate the way the vibration fell into and out of this.

Strong energy by using earthing feedback

I detuned and processed the signal of a shorted guitar lead. Depending on how I shorted the lead (contact with positive and negative parts of the jack plug) I could get an interestingly coloured, very strong low frequency energy (50Hz hum, then processed and detuned).

I experimented with pressing the lead against conductive surfaces and my own hands. This included ‘floating’ my hand around the plug, but not contacting, whereby some activation of the earthing field was obtained, but I was able to explore the boundaries of a strong tone.

What might have been a simplistic signal as audio was quite engaging as a sensation.

Collaboration

I collaborated with Jason Heller. His analogue synthesizer offered very low frequency tones, which were processed through delays and feedbacks.

The signal was sent in the table, while concurrently I employed the bass guitar and microphone feedback as above. The bass feedback built and escalated from the material coming in from synthesizer.

From the riddim exploration perspective, the material was interesting as the gritty synthesised tones had a slight sequenced step, offering riddim-like shifts in the frequency generated.

The microphone feedback and collaboration yielded a range of passages that I composed with.
Addressing my research aim

At this time I had tested the different approaches that could be taken to abstraction of riddim, addressing my research aim about ‘how effectively I can reference riddim in creation of sound works, and testing the issues associated with this linkage to musical contexts.’

Importantly, my reference point for abstraction of riddim was not that of the dance floor, but, as described in my proposal, the post-nightclub experience of being outside performance spaces such as warehouses, where riddim was naturally abstracted as the low frequencies passed through building structures.

At the end of Phase 6, I had developed an approach that captured the attributes of this movement from musical to environmental sound, without being bound to the explicit links to the music experience that came from directly using bassline material.

The approach I developed recognised the fundamental differences in perception of such sound in a stand-alone art installation context, from that of being in the street following exposure to high-intensity basslines.

In the post-nightclub state, the sonic artifacts of building vibration can become the perceptual point of interest.\(^1\)

However, my early research showed that this perception of the ‘environmental’ over the ‘musical’ elements did not directly translate when the sound was presented as a stand-alone experience.

When listening back to recordings from outside nightclubs, or blurred riddim activating spaces, the underlying rhythmic properties of the bass would seize my attention, over that of the environmental artifacts I was interested in.

Through this testing and later experiments, I concluded that the fundamental musicality of the underlying rhythmic pattern created such strength of association to music, that when using music-based material in this way I wouldn’t be able to effectively separate the audience experience from this musical reference point.

Recognising that this challenge was inherent to the different presentation context and listener experience, I moved to more abstracted approaches.

The use of undulation, while longer in its envelope than riddim, still captured the sense of materials responding differently to particular frequencies of sound, and the activation and release that came from musical basslines as they passed through a space. By avoiding direct use of bassline riddim, I could free up the experience to be about this environmental response.

From a pure sensation perspective, I also recognised that undulation represented an experience that was remote from that of riddim, being more suggestive of a mechanical context, such as vibration from engines.

The reasons for taking such an abstracted approach to vibration were much the same as for my approach to sound. However, the particular properties of vibration perception were also a significant factor that helped steer my approach to the smoothing out and stretching the change in frequencies.
I found that, when engaging critically with the table, the listener would become acutely aware of shifts in tone such as from a bassline.

The mode of experience, where a person was directly engaged with the vibrating surface, meant that a true bassline pattern would be too coarse and dramatic (compared with low frequency sound, which is naturally ‘smoothed out’ within a space).

Therefore, the use of undulation offered a way of touching on the sense of activation and release that came with bassline riddim, although in a different mode of communication, more tailored to vibration as a medium.

1. This is perhaps because of their contrast to the preceding intense musical experience, where there has already been a strong exposure to musical bass. The spatial aspects may also be a significant factor, as there can be a very different proximity to the nearby vibrating material, compared with the remote sound system that stimulates it.
During Phase 6, I worked with new materials and refined my techniques for sound generation. This helped me to develop a range of sonic textures that worked well together, without the need for supporting processed or synthesised sound.

Reaching this point helped to satisfy my research interests around how vibrating materials might be used in composition.

Building on my sensation experiments, I prepared a range of engaging sensations through the table, without complementary sounds.

To progress a whole audio-tactile composition, I activated a selection of materials through the table, using the material selected for bodily sensation.

Again I recorded a number of passages with windows and metal, but unlike with the ‘March table project’ I didn't employ smaller material such as glasses, bolts etc. I also worked with a large oil drum, activated directly by a vibration actuator, rather than via the table.

When activating the material, I dampened the surfaces with my hands to allow control over how much the sound developed into chaotic rattles. This offered a containment to the sound, in that the potential for vibration was expressed, but not fully realised as a noisy effect.

I used a pressure zone microphone in this case, as it had a 180 degree pick-up pattern, which better captured the overall character of the vibrating surfaces.

I also tested some recordings with contact transducers. However, my focus was more on the freely held microphones because of the flexibility for changing placement as the sounds altered in character and intensity. The microphone also offered a deeper and more complex sound.

Addressing my research aim

This work helped to satisfy my research aim concerning the articulation of building materials.
I had investigated artists who employed resonance of large strings\(^1\) or surfaces,\(^2\) those who worked with smaller, directly excited materials,\(^3\) and those who generated deep bass and corresponding resonance and/or vibration.\(^4\)

Acknowledging already covered areas, and appreciating the unique ability of the vibration table, had led me to a more internalised/personal approach to sound generation, where I was physically engaged through touch in the vibration and sensation when making recordings.

Through earlier compositions and tests, I had established that I could reveal a wide range of sounds from vibrating materials, from peripheral, sensation-augmenting sounds, to extreme rattles and distortions.

Understanding this potential range helped me recognise that moderate, contained vibrations were most complementary to my research aims and the vibration aesthetic I had developed.

By adopting this approach I could layer a more complex range of sounds than with gutterglass, and, in contrast to the ‘March table project’ experiments, the sounds also worked together naturally.

Having found an enjoyable and intuitive approach to working with vibrating building materials, I also had shown that the audible aspects of compositions could be based principally on this source.

I had generated a range of sounds that didn’t require augmentation or heavy effects processing to render an interesting and engaging result.

As these less dramatic sounds had a smoother, less punctuated character, they were also more suited to combining with vibration. The more gentle envelope was particularly appropriate when subtly separating the timing of the vibration and sound. The departures in timing could also be used more carefully as an effect, rather than a disconcerting by-product.
This overall research trajectory satisfied my research aims in this area, and developed a solid foundation for future application of my ideas.

1. For example, Alan Lamb
2. For example, Jon Mueller
3. For example, Jeff Jerman, Untitled Sound Objects
4. For example, Randy Yau and Scott Arford, Zbigniew Karkowski, Francisco Lopez
Presentation

Installation thoughts and the examination presentation context
Intended installation approach

The intended installation approach is to use the table, or iterations of this (such as a larger vibrating area, suitable for lying or sitting) with a close stereo or quadraphonic loudspeaker arrangement.

I would aim to offer an enclosed experience, by presenting the table within a small, darkened room or partition, and using the location of loudspeakers (as an indication of the listening location) and passage into the space as a passive invitation to the listener to touch, sit on or lie on the table.

The ideas leading to this approach have been developed over the course of the program, through dialogue with others experiencing the table and the works.

Ideally, with funding, I would offer a more constructed approach to the vibration installation, so that the table or a variation from this was integrated into the installation space. However, I intend to keep to an experience that invites sitting or lying, rather than just standing, as this offers a greater bodily experience and sense of being within the sound and vibration.

My thinking on spatialisation of sound is in keeping with this. My initial compositions included quadraphonic (plus vibration) mixes. I found that, beyond very minimal/subtle approaches, the surround effect was too perceptually engaging for the listening sense, which worked against the aesthetic I wanted from the combination of vibration and sound, where the auditory sense was ‘deactivated’ and folded into the vibration experience.

Guidance from audience and other feedback

In October 2007 (Phase 2), I installed the table at a dub/reggae gig. I used this opportunity to check some of the logistical issues with moving the table, and to test how people related to it in a public setting. The table was installed next to a wall and setup to synchronise with the music, supplementing the bass experience.

This installation showed highlighted the ways that people could engage with the table, and seeded ideas about the ‘method’ of inviting people to it in a public context, as it related to eventual gallery or public space installation.

I tried to both directly and casually gauge the reactions people had to the sense of an
additional bodily element to music and how this integrated into the music experience. Interestingly, composers and musicians at the event were more instinctively inquisitive and came back to it, asking questions and engaging with it by sitting and lying.

I came to the conclusion that for the table to work in installation, I needed to create some form of ‘passive invitation,’ i.e. not to direct people to the experience, but to allow a curiosity, by somehow suggesting that the table is sat on or engaged with somehow to experience sound.

Loudspeaker positioning would be the most simple answer to this, because an audience will recognise an ideal listening location by virtue of loudspeaker placement, which would lead to engaging with the table. The gig install was valuable in this sense, as it not only reminded me of the potential awkwardness of the system, but that there should be workable approaches around this.

I discussed my ideas during the various sessions with the Sound and Media Art postgraduate students and with Berlin based sound curator Elke Moltrecht, when she attended RMIT in 2008. These discussions really helped in refining my thinking and confirming that I was on the right track.

Also, in late 2008, I installed the table at RMIT and ran a number of sessions with questionnaires. Participants included postgraduate and undergraduate visual and sound arts students and other personal contacts.

I used this opportunity to present the ideas and the experiences I aimed for in the compositions, and to discuss the engagement with the table, the nature and intensity of the vibration experience, the way people responded to my approaches to aligning and pulling apart the vibration and sound components, and installation suggestions.

Some key feedback that helped guide my thinking are provided under ‘audience feedback’ below. People’s suggestions on installation in a space are incorporated in my comments above.

For the creation of new works, the main ideas that I gained were that:

- There were a range of expectations and preferences for the intensity of the vibration experience but overall the experiences I aimed for in making the works were well received.
- People focused more critically or intellectually on the work and phrases where there wasn’t sound with the sensation. The directly meshed pairing of sound and sensation helped in ‘sensory deactivation,’ which was an effect I wanted to continue working with.
- While there is scope to play with divergence in the levels and intensities of the sound and sensation elements, timing differences in more plosive and rhythmic elements tended to jar perceptually. I think these probably worked against established expectations based on the real-world experience of sound paired with sensation, i.e. during more dramatic or obvious sound and vibration events, the elements tend to more tightly coincide, because one low frequency stimulus generates both the sound and vibration.
More subtle passages of vibration might not work for a casual listener, depending on the way expectations were set up through the installation. For example, if a listener lay on the table during a subtle vibration passage, they may find the vibration ‘insubstantial’ and not stay to be drawn into the work. But if the installation was framed in such a way that the listener became involved at the beginning of the work, they may find the more subtle passages interesting, or appreciate them as part of the structure of the piece.

This feedback also clarified differences between what were effective experiments on the interplay between the senses, compared to engaging installation works, which may need to be less ambitious or conceptual.

However, comments suggested that careful framing of the experience through installation can help engage people in more challenging compositional structures, such as contrapuntal passages, plosive elements or more subtle vibration.

**Audience feedback**

My intended compositional outcomes seemed to communicate well to the audience - for example, the physical tension and release, auditory sensory deactivation due to the vibration, being physically relaxed but not in a wholly disengaged sense, direct engagement with the table in the vibration-only work, and greater relaxation and shut down of ‘critical analysis’ over the course of the work.

Similarly, the intended points of sound-sensation dialogue were generally positively responded to, such as the vibration supporting the sound, or shifting the dominant sense throughout the work. However, a couple of listeners felt that intended points of divergence between totally synchronous sound and vibration were not nearly as effective as synchronised parts (although they understood the intent of this after experiencing the works and reading the supplied notes).

Generally, totally synchronous sound and vibration seemed to be responded to most favourably. Some listeners picked up on the time-delay between the sensation and sound. I knew from my early research that this is something to which people have an acute sense, and that I could address this by closer loudspeaker arrangement or electronic delays.

People had a range of expectations for the intensity of the vibration. Most found the level of vibration appropriate to the experience and compositions, but some wanted a more intense experience. While the table is able to generate a strong physical experience, I chose to use shorter passages of this for effect within a work, rather than providing this kind of intensity all the time. This enables me to offer a broader range of communication, and greater subtlety in the sound-sensation dialogue.

I also recognise that while the table can offer an intense experience, this is not comparable to intense sensation from very loud low frequency sound. Sound can cause greater activation of the body through the vibration of the air and of the organs, whereas the deep textural oscillations through the table engage in a different way that is more about the body’s interaction with a vibrating surface. I haven’t tried to match or repeat the sound experience that people used to bass heavy music performance might be seeking.
Comments from three people suggested that when hearing just sound (before having access to the table), there was a psycho acoustic suggestion about what the vibration element might be. I inferred that this would likely be what we might expect from real-world sound-sensation experiences. The works aimed to play with this expectation.

However, having people hear the sound first was not helpful for the paired experience, as it established expectations about the vibration. This suggested that in installation it would be important to ‘contain’ the experience so sound and vibration are experienced together (i.e. avoid an audience wandering around listening without sensation).

Although there was generally very positive response to the combination of sounds and vibrations, there were also outlying responses on the mixture of the mediums, with one listener suggesting that they would have preferred just having the table, but another preferring just the sound from loudspeakers.

The works stimulated a range of ‘recollections’ in the listeners, such as: ‘lying in the ocean’, ‘transport, in particular flying’, ‘pins and needles’, ‘being in an earthquake’, ‘feeling like something is going to fall down’, ‘trance-like meditative state’, ‘synaesthetic’, ‘addictive’. After the works finished, people described feelings such as ‘fuzzy’ or ‘disoriented’ (these were positive descriptors).

People were comfortable (or enthusiastic) with lying to engage with the work, but recommended a softer surface, a longer, more ‘bed-like’ setup, and exploring materials that moulded to the body. Using pillows to minimise head vibrations was strongly supported. One listener suggested something like a reclined chair, although others noted the connotations to a massage chair.

One participant suggested baffling the table to minimise the audible noise during the vibration-only work. Another suggested exploring spatial vibration with multiple devices in future.

In the undulation composition there was a passage where the vibration was very minimal, intended to sit underneath the sound before rising to prominence. Some feedback suggested that in a normal ‘walkthrough’ installation sense, there was a risk of the listener leaving too soon. We discussed how this might be addressed through changing the works, or by defining the listening experience, such as a process of walking into the space at a set time, or enabling people to ‘push play’ to experience the whole compositional arc.
Logistical and technical notes

Around May 2007 (Phase 2) I completed construction of my vibration table instrument, working with an engineer, designer, acoustician and steel welder to construct a steel frame with MDF top.

This was an 8-12 month process of technical and design refinement, aimed at creating an instrument, which principally activated the body without causing unneeded sound.

The facing images indicate some of the design work that went into making the table - table design (assistance from Jerome Frumar) and calculating materials usage and mass.

My early (theoretical and testing) research in SIAL, and presentations during the course of the research also assisted my understanding of the electronics setup component of using the table in an installation context.

For example, in an installation for a dub/ reggae gig in October 2007, I had to consider compression, limiting, equalisation and delays, to best align the vibration to the music being played through the soundsystem.
The following gives an overview of the low frequency sensation tests conducted as part of my design research project. The tests were undertaken to aid an informed design process for my music vibration system, as well to gain further understanding of the role of sensation in amplified music experience.

Each test evaluated a different aspect of low frequency sound, vibration and relationships of these aspects to music experience. Tests took an average duration of forty minutes, with sound used intermittently throughout the test duration. The tests, which took place over two nights, were conducted with one participant and myself in the room. Three tests were performed with five participants, three females and two males. Mean age of participants was 30 years.

Tests were conducted in a storage space next to the SIAL N space. The room dimensions were measured and room resonance calculations were applied to determine a listening location that was least influenced by room acoustics. Once installed, the audio system was tuned to yield a reasonably uniform response at low frequencies.

Before testing, sound level readings were taken and used to calculate safe listening periods for participants in accordance with Workcover Safety and Ethics Guidelines. Maximum sound levels were set in accordance with these guidelines. However, participants could choose to have the sound levels reduced at any time if they wished.

Test 1: Swept, pulsed pure sinusoidal tones from 15Hz – 100Hz. Acoustic system engaged for the entire frequency range. These tests were to evaluate relationships between frequency and sensation in the body. They were also used to familiarise participants with high-energy low frequency sound and to stimulate an articulation of bodily sensation.

Test 2: Swept, continuous pure sinusoidal tones from 15Hz – 100Hz. Acoustic system filtered with substantially less energy below 70Hz, vibration system engaged below this point. These tests were to identify the types of sensation differences between acoustic and vibration energy and the transitional points between the two systems as identified by participants.

Test 3: Music test tracks played through the acoustic/vibration system. The system was alternated between two configurations: Full frequency range acoustic (as in test 1) and acoustic/vibration (as in test 2). These tests were to evaluate the effectiveness of vibration technology over a range of test tracks with different frequency emphasis.

Findings:

Test 1: Swept, pulsed pure sine tones, acoustic only.

Results were hugely variable. While some participants shared similar bodily sensations/responses to certain frequency ranges the overall range of responses and sensitivities suggests no uniform conclusions. I believe that aspects that contribute to this variation are:
- Very different sensitivities of participants. While some participants would clearly articulate frequency specific sensations, others did not identify any specific responses. Overall, female participants provided much more articulate responses to sensation and other effects.

- Audio system interference. Due to safety guidelines, system performance did not allow enough acoustic energy to explore acoustic sensation adequately. Also, the audio system performance was not entirely flat in response. This was because of loudspeaker design artefacts as well as relatively crude methods of calibration.

- Room interference. The reverberant properties of the room in terms of both low frequency resonances and distracting resonant noise (from air conditioning, outside stairwell, windows etc) affected sound energy and did not provide a critical listening environment for participants.

- Test procedures. My approach to prompting feedback from participants changed thought the tests and this may have affected the level of feedback.

Findings of interest:

Sensation

My expectation from observation of other research was that bodily sensation would shift from area to area with an increase of frequency, largely in relation to resonant cavities (in or around organs) in the body. However, sensation shifted from organs (eg in belly or chest) to areas (eg legs, upper body) to surface skin effects and zones such as the ears or nose, and would shift back and forward throughout tests. Other effects included a sense of vertigo and a feeling of tiredness occurring with specific frequencies. This suggests the myriad of low frequency effects found in amplified music as well as the multiple senses engaged. I believe that significantly more absolute results would only be achieved with very high sound pressure levels in a highly controlled environment.

Space

One participant identified certain frequencies as occupying different heights and locations in the room, shifting with changes in frequency. I am uncertain as to the acoustic effects (from loudspeakers and the room) and the psychoacoustic contributions which generate this response. Experimentation with 'placement' of low frequency sound and its more tangible, locatable properties could be investigated through more tests combined with room resonance analysis. This would inform composition that explores interpretation of specific spatial experience through low frequency sound.

Skin

There was a correlation between three participants in identifying a frequency where the effect of sound became less 'bodily' and more of a skin surface effect. Two participants identified this as a tingling sensation rather than an internal sensation, and one described a feeling of being cold. As no other sensation effects were as consistent between participants this frequency may identify a predictable transition point between sensation and auditory perception of sound. The frequency sits near my estimated 'cut-
off" frequency determined to be the upper limit of effectiveness for a vibration system. Investigation of this relationship will be extremely interesting as I believe it is currently unexplored.

**Test 2: Swept, continuous pure sine tones - vibration/acoustic system.**

Outcomes from these tests have suggested that identification of forms of fusion between vibration and acoustic perception is quantifiable, but that the articulation of transitions between these senses is difficult.

**Findings of interest:**

**Sensation**

By comparing acoustic energy with direct vibration energy I have come to understand the fundamental differences between these modes of communication. Using the vibration floor did not simply replace the acoustic energy with a more direct sensation interface. The qualities of sensation were fundamentally different, being more grounded in the body. Overall, at most frequencies participants found that they were more comfortable with vibration energy than with the acoustic only system. Vibration sensation 'bodily placement' did not correlate with findings from the acoustic only system, suggesting that the way the body is excited by direct vibration is significantly different. While some effects were specific to the vibration system, such as a sense of the feet shaking, the range of sensations experienced were board, including effects in the upper body, face, legs and back. This indicates that a vibration system is appropriate for generating a range of frequencies and spectral content and that its effects are not limited to feet or leg focused sensation.

**Perception**

Perception of auditory effects was also affected by the vibration system. Most participants did not perceive acoustic energy in the room until acoustic levels were much higher than normal perceptual thresholds. I believe that this is because vibration and acoustic energies mask each other, with increased vibration effects reducing acoustic perceptual sensitivity.

One participant identified a frequency where they felt that their focus was flipping between the vibration and acoustic system, at a point where both energies were perceived to be at similar levels. This suggests that, although there is some degree of perceptual blending with combined vibration/acoustic energy, potential exists for sensory confusion when the two sources of information are similar. Similarly, tests with music tests tracks suggest that vibration and acoustic perception, although working together, compete with and affect each other’s characteristics.

**Transition**

Four of the five participants identified a specific frequency where perception of energy shifted from the vibration to the acoustic system. This frequency was the same for all four participants (within a 1Hz tolerance). This finding illustrates that specific transition points between perceptual modes can be identified. However, I believe that this point is fundamentally determined by loudspeaker, vibration system and room characteristics.

With further analysis I intend to develop situation-specific system tunings to explore
this aspect of low frequency experience in relation to the electro-acoustic environment. This research will assist system calibration as well the development of sound and music composition approaches that enhance perceptual fusion in vibration system installations.

**Envelope**

Further tests were briefly conducted with four participants, exploring sensation differences when using continuous test tones compared with the pulsed tones used in initial tests. These tests did not provide definitive conclusions. However, the perceived relative strength of vibration effects did change when the envelope of test tones was filtered. These strength characteristics were not consistent across the full frequency spectra, but the previously observed transition frequency from vibration to acoustic systems remained the same. Preliminary findings suggest the significance of rhythm envelope for both acoustic and vibration perception. This indicates that in future composition for vibration systems, envelope as well as spectral content and psychoacoustic effects will have to be considered.

**Test 3: Music test tracks played through the acoustic/vibration system.**

The complex responses to music reproduced through the acoustic/vibration system have developed my understanding of personal engagement with music technology and related composition characteristics that affect electro-acoustic music experience. Overall, responses were mostly consistent between participants and preferences towards vibration system reproduction were expressed.

**Findings of interest:**

**Engagement and Association**

Most participants quickly found that they became more involved with music when the vibration floor was engaged. In addition to compelling more attention to the music, the floor itself became something to interact with and was missed when deactivated. This association was strongly noted by most participants while listening to the first piece of music, with later tracks evoking more critical descriptions of comparative effectiveness. Descriptions included: the floor creating a nicer experience because sensation was more bodily; feeling more involved and consumed; increased awareness of high frequency sound; increased awareness of low frequency sound; quick association with the vibration experience; and that the floor created another level of interaction, or relationship. In the context of comparative testing against the acoustic only system, the vibration interface itself often became essential to the music experience, translating and extending the qualities of the music used.

**Acoustic Noise and Masking**

In most tests the acoustic only system was less enjoyable for participants. When in acoustic only operation the strongest responses were that the sound failed to engage, being washed out or lacking in weight compared with vibration assisted reproduction. Because the acoustic energy did not involve the body as directly, low frequency information was less tangible and less defined. One participant found that it was harder to interpret the
bass with the ears only and other responses indicated that the music seemed more muffled or muddier. The extra acoustic energy usually detracted from the qualities of the music, as the increased air pressure was less comfortable and excited more noise from the room itself. In some cases the extra sound was perceived to be a less enjoyable force, pushing at participants rather than engaging the body directly.

I have observed that when engaging full frequency acoustic information, the added sub-bass reduced overall intelligibility of music, masking the higher frequency information. This effect may have been more pronounced due to the small size and reverberant properties of the room.

I believe that this finding illustrates a key aspect of amplified music experience. At many large-scale events the acoustic energy excites vibration in the room, creating resonance along surfaces such as the floor - accessing the body through a direct physical medium. The acoustic energy itself does not contain all the properties needed to achieve an enjoyable response. Rather, it excites vibrational energy to further enhance music experience. Chasing this level of physical excitement requires acoustic levels that are harmful to hearing and can detract from the music’s accessibility by masking other sounds. This finding would need to be tested in larger scale systems to verify its accuracy.

Fusion and Competition

The added depth given through the floor in the lower frequencies was not substitutable with acoustic energy, which failed to deliver the same type of internal sensation, partly due to (relatively) low sound levels as well as its overall characteristics. However, in the higher bass frequencies acoustic and vibration energy became more similar in sensation qualities.

Envelope

Participants favoured the vibration interface in tracks where low frequency rhythm was not overtly punctuated, having a rolling or fuzzy quality. Dub and Drum ‘n Bass tracks with this type of bassline produced best results. More punctuated rhythm appeared to highlight differences between acoustic and vibration information, perhaps because the chronological space of definite ‘beats’ promoted more critical perceptual processing. The envelope of synthesised bass also appears to determine the characteristics of the interface. Tests suggest that sine wave bass has a more embracing tonal quality with saw waves having a comparatively sharp or abrasive effect. I intend to explore this aspect with a greater range of test tracks and compositions in the future, to assess the effectiveness of sensation properties of different genres of music.

Appendix A

Each test track chosen had a different frequency emphasis, enabling participants to evaluate the musical effectiveness of vibration technology over its entire operating range. Results favoured pieces of music with frequency content extending into the very low frequencies (20-45 Hz) where the contribution of the floor was felt to be more essential. Tracks where frequency emphasis was centred closer to the upper operating frequency of the floor still benefited. However, vibration effects became more noticeable as buzzing or were perceived to be located in the floor, rather than a logical extension of audible sounds. This may partly be due to the type of technology used.

Frequency

The added depth given through the floor in the lower frequencies was not substitutable with acoustic energy, which failed to deliver the same type of internal sensation, partly due to (relatively) low sound levels as well as its overall characteristics. However, in the higher bass frequencies acoustic and vibration energy became more similar in sensation qualities.
Participants found that when low frequency was distinctly different from high frequency information the floor failed to enhance music experience. Rather, with acoustic and vibration senses processing separate information, the floor became a distraction and could be disorientating due to lack of cohesion. This was primarily noticed on one track, which had an atypical gap in information between low and high frequencies. All other tracks contained some degree of acoustic ‘artefacts’ in upper harmonics of the predominant (vibration sensed) bass information, which possibly aided in tying sensory information together. I believe that this aspect strongly relates to the envelope characteristics noted above, as sensory gaps appear to be more acutely noticeable when music is punctuated.

**Timing**

One aspect that determined the effectiveness of the vibration interface was the arrival timing of sensory information. Because sound travels through air slower than electrical signals, information sent to the floor had to be delayed in respect to its distance from the loudspeakers.

Delay between arrival times could reduce the perceived clarity of the music. This was most clearly noticed with music having highly punctuated rhythm and at the beginning of, rather than during, passages of low frequency information. In this sense vibration perception is similar to auditory perception, as sound also suffers from reduced intelligibility when acoustic events are delayed from each other.

A large-scale vibration installation would require a range of delay times over its surface to compensate for increased distance from loudspeakers. To understand required delay intervals and allowable timing offsets I intend to assess this aspect of perceptual fusion. I believe that delay offsets would be allowable within fairly broad guidelines, with reduced intelligibility having a relatively wide margin of error compared with sound. However, this may shift in respect to frequency and amplitude as well as individual sensitivities.

**Scales of Perception**

When combining vibration and auditory information, one of the most fascinating findings is the sensitivity difference between the two forms of perception. Sound is perceived in a logarithmic scale, using the dB unit of measurement. However, vibration is closer to a linear scale of perception. Therefore, small changes in dB level result in large changes in vibration level.

This was evidenced when small adjustments were made to levels being sent to the vibration floor. Incremental adjustments that are barely noticeable to hearing (1-2dB) produced significantly more apparent levels of vibration. Also, as levels increased within a track, vibration effects became extremely pronounced, to the point of being overbearing. Although intensifying the experience it significantly altered the balance of the music in an undesirable sense.

This effect was reduced through system compression, which adjusted levels sent to the floor to fall within a more restricted dynamic range. However, as audio adjustment and tuning uses a dB scale of measurement, these settings were fairly arbitrary.

In order to understand how to best tune and
manipulate a vibration system that uses an
acoustic point of reference I will need to more
fully understand the relationship between
both senses. In amplified music, as well as
everyday life, acoustic experience incorporates
vibrational energy. In creating a vibration/
acoustic experience I will need to further
understand the way that we perceive this
combined force.

I have not yet seen any exploration into the
combination of these forms of perception.
A significant amount of studies exist on
perception of sound. There is also research into
perception of vibration, using different forms
of measurement. Significant research into the
combination of senses and related perceptual
effects has yet to be investigated. Exploring this
aspect of acoustic experience will not only aid
an informed design process but also develop
further understanding in an under-researched
field.

Technical Notes

Frequency Analysis:

Each test track was processed in audacity after
being normalised. Analysis of three to five 30
second sections of each track were exported
into excel, where they were sorted and edited
according to level. Once listed in excel, average
concentrated values were evaluated and tracks
were listed according to frequency emphasis.
Chosen tracks had emphasis ranging from
30Hz up to 85Hz.

Room Resonance Calculations:

The test room was modelled as a rectangular
space to calculate axial modes. Two models
were generated to determine the best section of
the room for testing. The calculator, written by
myself in excel, incorporated input for average
room temperature, width, height and depth
and calculated axial modes including harmonic
resonances and upper and lower predictable
frequency limits.

Determination of Loudspeaker System

Tests at Rent the Rig and Warehouse Sound
Systems were undertaken to assess equipment.
Tests were done with SPL meters and overall
level capability as well as frequency response
efficiency were determining factors in system
design. The combined system had the best
balance of low bass extension and efficiency for
available budget.

Crossover

The crossover point of 70Hz was chosen from
previous tests with smaller scale systems,
according to my personal preferences. 24dB/
octave Linkwitz-Reily crossover slopes were
used for both vibration low pass and sub
high pass. This resulted in minimal acoustic/
sensation crossover. Results suggest that the
vibration crossover roll-off would suit a gentler
slope, but this would be dependent on the
actual installation. However, I am reasonably
confident that the chosen crossover frequency
reflects a real perceptual transition point.

Vibration Tuning, System Compression:
The vibration system signal had approximately
6-10 dB of compression, with peak limiting.
The primary subwoofers (2x 18”) had no
compression, with peak limiting. The Mid-
high loudspeakers (4x 15” and 2x 2” Horns)
had 2-6 dB compression, with peak limiting.
The system controller has compression over its
input. The max patch and a desk were used for
level adjustments and compression was set in relation to this operating range. In future tests I intend to use software level adjustments where possible to ensure more uniform, accurate results.

**Safe Sound Levels:**

Levels were determined in relation to Workcover guidelines: L_{eq85}dB, 8hr. Calculation: To work out a level based on a given Leq over time (T), and a time you want to use (t)...

\[ L(t) = L_{eq} + 10\log\left(\frac{T}{t}\right) \]

Average 45min duration:

\[ L(0.75) = 85 + 10\log\left(\frac{8}{0.75}\right) \]

\[ L(0.75) = 95\text{dB(A)} \]

All average values were below this point, with peak sound levels well below the maximum of 140dB(C). A B&K SPL meter was used to monitor levels. Music listening levels were measured in dB(Lin), average values at 112dB. Swept tones were also within 110-117dB(Lin) range. dB(Lin) measurements were the acoustic reference during tests, with dB(A) levels calculated according to previous analysis during setup, as listed below.

<table>
<thead>
<tr>
<th>Track</th>
<th>Measured dB(C)</th>
<th>Measured dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rwanda</td>
<td>112-114</td>
<td>95</td>
</tr>
<tr>
<td>Scorn</td>
<td>110</td>
<td>95</td>
</tr>
<tr>
<td>Etherealites</td>
<td>109</td>
<td>95</td>
</tr>
<tr>
<td>Rhythm + Sound</td>
<td>112</td>
<td>93</td>
</tr>
<tr>
<td>The Bug</td>
<td>116</td>
<td>95</td>
</tr>
<tr>
<td>Brian 2K</td>
<td>116</td>
<td>97</td>
</tr>
</tbody>
</table>

Reference for Workcover:

**Recordings and tuning:**

Recordings were made to test the system, with sweeps and pink noise. A pink noise test was used for tuning and parametric eq adjustments were made according to measured octave band levels. This resulted in a ‘flat’ bass response as measured on the meter. However, anomalies were still present, partly due to loudspeaker design as well as the rough method of calibration.

**Results:**

In swept tone tests participant responses were recorded and tabled in excel, listed by frequency. This was used for response analysis. Original notes were used for assessment of response to music tracks.

**External Noise and Reduction in Level:**

Whilst the system was running I walked around the building and surrounding areas to assess noise impact. Air conditioning and windows were the most obvious sound transmission paths.

System tuning offered promising results in terms of level reduction for external areas. I measured dB(Lin) levels in n-Space, against the wall next to the entrance into the postgraduate room.

I achieved a 10dB drop at sub bass frequencies, indicating the real noise reduction potential of vibration technology. Real benefits would best be assessed with octave band or finer measurements, in a variety of measuring locations.
Altinsoy, M. E. Audiotactile simultaneity of musical produced whole body vibrations. Bochum, Germany, Institut fur Kommunikationsakustik, Ruhr-Universitat Bochum.


Altinsoy, M. E. Inter-modal effects of non-simultaneous stimulus presentation. Bochum, Germany, Institut fur Kommunikationsakustik, Ruhr-Universitat Bochum.


Delgarno, G. A vibroacoustic couch to improve perception of music by deaf people and for general therapeutic use. ICMPC6


Martens, W. L. Human-centered design of acoustic and vibratory components for multimodal display systems. Montreal, Faculty of Music, McGill University.


Appendix C

Discography

Asano, Koji, *Sunshine Filtering Through Foliage*, Solstice, [CD], 1999

Asano, Koji, *Momentum*, Solstice, [CD], 2000

Behrens, Mark, *Integração*, Sirr [CD], 2004


Cook, Perry, *Real Sound Synthesis for Interactive Applications*, AK Peters, Ltd [CD], 2002

Charles, Xavier, *la neige attend la neige*, a bruit secret [CD], 2004


Galbraith, Alastair / De Gennaro, Matt, *From the Dark (South Island)*, Xeric [CD], 2006

Glass percussion project, *intermezzo*, Eugene Ughetti [CD], 2008


Jerman, Jeff, *Instability Studies*, Anomalous Recordings [CD], 2003

Karkowski, Zbigniew / Davidson, Xopher, *Function Generator*, Sirr, [CD], 2003


López, Francisco, *Temizlemek* [extract cited], Linea Alternativa [CD], 1998
Pinch, *Underwater Dancehall*, Tectonic [CD], 2007

Piccinini, Patricia, *the breathing room* (Exhibition description and Video), [Online], Available [http://www.patriciapiccinini.net](http://www.patriciapiccinini.net), April 2007

Sunn O))), *Black One*, Southern Lord [CD], 2005

Scorn, *Plan B, Hymen*, [LP], 2002

Scorn, *Stealth*, Ad Noiseam [CD], 2007


Tsunoda, Toshiya, *O Respirar Da Paisagem*, Sirr [CD], 2003


Tsunoda, Toshiya, *Extract from field recording archive #3: Solid Vibration*, Infringitive [CD], 2001

Untitled Sound Objects (Pi Lang and Zimoun), installation videos, [http://www.untitled-sound-objects.ch](http://www.untitled-sound-objects.ch)

Von Hausswolff, Carl Michael, *Strom*, Raster-Noton [CD], 2001

DEGREE: Master of Arts

BY: Project

WITHIN THE SCHOOL OF: Art & Culture

TITLE OF THESIS/PROJECT: Physical in Sound: An exploration of vibration and sensation within experience of sound

SUMMARY OF THESIS/PROJECT:

This project will explore audible resonance and vibration in architectural spaces; and the physical sensation of sound, felt as vibration in the body. Through composition and installation, I intend to explore characteristics of these and the associations they carry to experiences of sound and place.

SUPERVISORS AND CONSULTANTS (Please state affiliations):

Senior Supervisor: Darrin Verhagen (School of Art, RMIT)

Supervisor: Dr Philip Samartzis (School of Art, RMIT)

3. THE RESEARCH PROGRAM:

3.1 Title: Physical in Sound: An exploration of vibration and sensation within experience of sound

3.2 WHAT? Brief Description:

This project focuses on felt and heard vibration, how they are perceived and how they contribute to the experience of sound in a space. Through composition and installation I aim to explore vibration as a product of low frequency (i.e. bass or low pitch) sound, extracting material from musical contexts where sensation from sound is emphasised.

As low frequency sound passes through a space it can stimulate vibrations in the building structure. These vibrations may be experienced physically, through the transmission of energy from the building and into the body, and/or may create vibration sound that is experienced aurally, such as rattles from fixtures or windows.

My interest is in the characteristics of these vibrations and how they may convey connections between sound and the physical aspects of the body or a space. I will explore the idea that vibration, both heard and experienced physically, can change a person’s perception of sound. I aim
to do this through a series of compositions/presentations, culminating in either a sound/vibration installation project in a gallery or a live performance using vibration sound.

The research includes development of a specially designed 1.2m2 tactile “floor” system that translates sound into strong vibration that may be heard and/or felt through touching or standing on it. This will be used to create vibration material for composition. With this I intend to explore relationships between the felt and audible aspects of vibration and how each affects perception and awareness of the other. I will explore possibilities of using the tactile system in performance as an instrument and in installation as a way to create physical sensation for a listener.

The objective of this project is to develop compositions/installation that communicates my findings on felt and heard vibration. I aim to create works that draw association to listeners’ past experiences and engage with the way vibration is perceived. I also aim to incorporate vibration technology into sound installation works. To achieve these objectives I ask the following research question:
- Through sound design and composition incorporating sensation technology, how can I use physical vibration to draw attention to the role of the body in the experience of sound, and how can I draw upon vibration in musical contexts to achieve this?

Influences in work looking at vibration include the “Infrasound” performances by Randy Yau/Scott Arford and Koji Asano’s “Rift in the cloud”. These use low frequency sound to stimulate resonance and vibration, drawing attention to architectural and acoustic qualities of a space. These works articulate ideas of interest around characteristics of vibration (such as rhythmical, tonal or spatial qualities) and their relationship to low frequency sound. I also intend to focus on harmonics in vibration, and the tonal connection between low frequency sound and related high frequency vibration. In investigating this principle I am inspired by the work of Alan Lamb, whose compositions with large scale wires engages the qualities of harmonic vibration in objects.

In exploring these themes and characteristics within my own work, I am focusing on environments with a strong and unique association to felt and heard vibration. These are specific contemporary “dance” music performance contexts, where high levels of low frequency sound (as bass in music) stimulates physical responses from the body and the architectural environment. In looking at these contexts as a reference point for my work I am able to draw upon the unique properties of vibration within music experience, such as its strong physical aspects, and tonal/rhythmical qualities. I will investigate how vibration in these contexts can be rearticulated and abstracted in composition. A focus will be on the natural processes of abstraction that occur when music passes through a building and creates audible vibration; and how the resultant sound can shift from being musical, to either unfamiliar or registered as environmental in nature.
3.3 WHY? Rationale for program:
This research will present a range of composition and installation approaches to inform the broader field of sound arts. Through the production of work focused on the physical in sound, discourse will be encouraged to progress knowledge in this field, stimulating reflection within the sound arts community on the significance of vibration in the experience of sound.

Audible Vibration

I feel that because of its subtle, physical role within a space, audible vibration can carry strong associative weight to experiences of place and sound. I intend to explore these associative connections and how they may be drawn upon in the creation of works.

The main association that I intend to explore is the perceptual connection between audible vibration and the low frequency sound that has stimulated it. I am interested in how, through composition, I can express vibration perception as falling within a continuum, with its character changing as low frequency sound and the intensity of vibration increases. This range includes vibration that is barely noticed, to vibration being a related part of low frequency sound (such as a car stereo causing the rattling of the dashboard or doors, which act “responsively” and may feel like an aspect of the music itself), to being independent, contrasting or discordant sound (for example, vibration of a bedroom window transforming otherwise innocuous ambient low frequency sound into something that feels physically present or even intrusive).

I perceive these types of connections to be largely integrated and subconscious aspects of experience. Given the way they are experienced, I believe that these interactions between sound and space offer strong potential for compositional exploration. By drawing upon different characteristics of audible vibration, I hope to trigger the potential subconscious points of reference they have to an audience’s experience of sound and encourage reflection on the way a space responds to vibration energy.

Felt Vibration

Physical sensation in musical contexts provides a strong and evocative sensory foundation from which I can investigate the dialogue between hearing and sensation, and how physical vibration can augment the experience of sound. Being so strongly tied into particular experiences of music, I am interested to see how these physical aspects can be reinterpreted outside of their original contexts.

To develop this enquiry, I am interested in scientific research that looks at the general perception of combined sound and vibration. Such studies will help me to better understand how people may respond to vibration and to develop composition for the new medium of vibration technology.
For example, in previous testing (SIAL, 2004) I found that where heard sound and vibration had similar properties (such shared timing between felt and heard sound and overlap in tones between the two senses), people found vibration and hearing to be mostly integrated and that the vibration changed the way in which the overall sound was perceived, making it more immediate or intense. Conversely, when vibration was tonally very different to the sound, people felt like they were not connected and that the experience was disconcerting.

I aim to integrate ideas about sound/vibration perception in the creation of installation works, using vibration in musical contexts as a primary point of reference. This research aims to explore the points where vibration is integrated into the experience of sound in a space and the crossovers between vibration that is heard and vibration that is experienced physically. The work will enable me to evoke the experience of these aspects of sound in space and reveal (and potentially manipulate) the peculiar relationships between our physical and auditory senses.

3.4 HOW? Methods:
Key project components are described below.

Mid to late 07:
- Construction of the tactile system (floor): involves steel fabrication and installation of its wooden top. A variety of installation options will be experimented with, such as placement of bolts and vibration absorption.
- Developing software for the floor: involves a combination of equalisation, filtering, timing offsets (delays) and compression. This will be trialed in various software, including max/MSP and Logic.
- Environmental recordings: Involves recording material from the areas around music venues and other environmental sources of low frequency sound, including traffic and mechanical sounds.
- Test and record material for space excitation: Using recorded and synthesised material to stimulate vibrations in chosen spaces. Recordings will be made in two to three sites, using musical low frequency material, abstracted to focus on environmental effects from the sound.

Late 07 to late 08:
- Develop material for tactile system: audible and felt: Using gathered and new material to explore the use of the tactile system as an instrument. Focusing on the types of sounds that work with the tactile system, and the ways the system can be manipulated or “played”.
- Composition drawing upon audible vibration: Exploring ways in which recorded material from the tactile system can be used in broader composition, and how the tactile system as “felt” vibration device may work with “audible” vibration as played through loudspeakers. May incorporate other sounds and recordings, other than those from the tactile system.
Mid to late 08:
- Trial Performance: Presentation and audience evaluation within a space such as the RMIT media arts theatrette. To seek feedback from peers about how the tactile system may work as a life instrument, and how composed and improvised material work together artistically.
- Trial installation: Presentation within a student or other local artspace. Envisage a small room, use of the tactile system with loudspeakers, combining tactile and audible vibration in an integrated experience.

End 08:
- Final outcome: live or installation: To be informed from previous trials and evolution of work. Seek to include tactile system in a primary way within the outcome.

Ongoing:
- Research: other artists, works etc exploring similar themes. This ongoing research includes literature searches and listening to compositions in the fields of interest. See bibliography for an initial list of works and artists.

Ongoing (peripheral):
- Max/MSP: Explore potential of Max/MSP software framework to generate sounds evocative of audible vibration that can be more freely manipulated and shaped than recordings, particularly for real time uses. I will continue to explore the viability of this option as a peripheral aspect of the project.