The AirSticks: A New Instrument for Live Electronic Percussion within an Ensemble

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Certificate of Original Authorship

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Abstract

This research explores the design of a new gestural instrument for electronic percussionists, the *AirSticks*. For the purposes of this work, a gestural instrument is defined as one which can, through some form of motion capture and the process of mapping on a computer, convert physical movement data into sound. The infinite ways of mapping this movement to sound is identified within as the 'mapping problem.' The aim of the research is to investigate different approaches to tackling this mapping problem within diverse collaborative musical situations to help overcome 'creative paralysis.' The method has been to use practice-based research to develop a series of mappings of the instrument for use in dozens of distinct projects which follow on from the researcher's own creative practice as a drummer and electronic producer.

Self-reflections of the researcher's role as performer/designer are provided, along with observations of working closely with a computer programmer and several expert musicians, dancers and visual artists. These reflections suggest that many different approaches are needed to tackle the mapping problem, and that laying out a clear artistic goal for a project can at least get the designer through some of this creative choice paralysis and more difficult decisions that need to be made. Considerations of how the performance may look, sound and the degree of control given to the performer leads to different mapping approaches. Mapping approaches are also influenced by whether the performance is improvised or composed, filmed or simply recorded, the size of the ensemble, the skillset of the collaborators and the genre conventions of the piece.

To enable this research, the AirSticks were designed to allow the composition, improvisation and performance of live percussive electronic music using hand and finger movements captured by gestural controllers, enabling the control of complex sound textures at the same time as allowing the performer to time and execute precise rhythmic gestures within various collaborative musical situations. A background to the field of electronic percussion in new instrument design with a focus on the use of gestural controllers is provided. The reasoning behind the choice of a particular gestural controller is discussed, as are the artistic motivations behind the project. The technical and creative components of the work, including custom software and the use of off-the-shelf controllers and sensors, are also outlined.

As part of this project, more than one hundred musical situations on the AirSticks were documented. These musical situations included live performances, films and recordings, some in solo form, but most with collaborators. Some video documentation is linked to within the thesis to help demonstrate the workings of the instrument and showcase the instrument within these projects. A detailed overview of these projects is presented along with insights into the creative and design processes. A discussion of the different 'things to consider' when designing an instrument such as the AirSticks is followed by the outlining of future projects and the design criteria of future software and hardware.

Contents

Chapter 1:

Introduction

1.1 Introduction

This thesis documents the developments of a new instrument for the live performance of electronic percussion that has emerged from my creative practice both as a drummer and electronic producer. As a drummer I have desired, as many drummers have, for a way to integrate electronic sounds into my live, mostly improvised drumming performances. As an electronic producer I have desired, as many electronic producers have, for a way to present my beat oriented electronic music in a truly live context, and be able to freely improvise around structures produced in the studio. These desires led me to the world of instrument design, the investigation of motion capture technology, and the creation of a new gestural instrument for electronic percussion, the **AirSticks**, that could combine the physicality of playing drums with the endless possibilities of electronic music.

A major factor in the design of the AirSticks was that as a drummer, the vast majority of my performances were within ensembles, while as an electronic producer I yearned to collaborate with others in the studio but often lacked the tools for true collaboration short of taking turns on the computer. This inspired the desire to make a truly ensemble instrument, allowing a merging of the roles of drummer and electronic producer to enable ensembles to improvise, compose, arrange, rehearse and perform electronic and electro-acoustic music in a more collaborative manner.

At the commencement of this practice-based PhD research project, I had already created a working prototype of the AirSticks with the help of computer programmer Mark Havryliv and the use of off-the-shelf gestural controllers. Much of what I desired to do in my creative practice had now become possible. I embarked on several collaborative creative projects with a broad range of musicians, visual artists and dancers. These projects not only served in developing my artistic practice as a musician but also formed the core of my investigations for this research project. These projects in themselves demonstrate one of my main arguments about the state of the field of instrument design: that the most significant challenges in the field will only be overcome through performers devoting much time to developing and learning different mapping scenarios and maintaining a routine of practicing these new relationships between movement and sound in diverse collaborative musical situations.

While working in over a hundred musical situations with the AirSticks, developing this practice routine, collaborating with dozens of professional artists, setting hundreds of deadlines and constantly reworking the instrument for public performances, I gathered observations and made reflections on the process of designing and developing this new instrument. The core contribution of this thesis is the collecting and categorising of these observations and reflections through a discussion on different approaches to tackling what Maes et al. (2010) refer to as the ‘mapping problem’ which I define as the choice or ‘creative paralysis’ (Magnusson 2010, p.62) felt by instrument designers when faced with the infinite ways of connecting movement and sound in electronic music. Since the connection between

movement and sound is arbitrary and does not exist in the natural or physical world like in acoustic instruments, the digital musical instrument designer must make very conscious and clear decisions as to what this connection (or connections) should be, often leaving them with too many options to know where to start. This thesis investigates and discusses the various entry points into the mapping process, and hence the different ways of overcoming 'creative paralysis' in tackling the 'mapping problem.'

It is worth noting here that I myself am not a hardware engineer, nor am I a computer programmer. I am a drummer and an electronic producer whose specialty in the field of instrument design lies in imagining ways that we can use the body to improvise, compose and perform electronic music. Throughout this thesis I will stress the need for pushing our imagination through practice and experimentation.

It is also worth noting that this thesis will focus on my dedication to create a gestural electronic untuned percussion instrument within the context of ensemble playing. I have explored the AirSticks in solo contexts and as a tool for playing melodic ideas, but my key focus will be on the design of an instrument that utilises the motor skills of an expert percussionist, staying clear of the use of loops and maintaining a one-to-one mapping relationship between movement and sound, prioritising transparency, controllability and expressivity to the highest possible degree.

This thesis will take the form of a narrative of the creation and development of this new instrument within the narrative of my own artistic practice. I will document:

- the instrument's emergence in my creative practice,
- breakthrough discoveries in both hardware and software,
- pivotal projects that reshaped and redefined my own practice and the practices of those who chose to collaborate,
- reflections on and discoveries from these projects in tackling the mapping problem,
- design criteria for future software and hardware, and
- strategies for making the instrument available for use by other people.

To help tell this narrative, this thesis will be split into seven chapters. Following ***Chapter 1: Introduction***, a literature review of the state of the art that includes instrument design, electronic production, electronic percussion, improvisation and collaborative music making will be woven throughout, but mostly contained in ***Chapter 2: Background***. In Chapter 2 I will outline my own experiences in the field of acoustic percussion, electronic percussion and electronic production, including my initial informal design criteria for a new gestural instrument for electronic percussion within an ensemble. I will also lay out four research questions here.

I will then give a brief history of percussion instruments, from the most primitive acoustic percussion and their relationship to the body and dance, to current gestural (or open-air) controllers as I evaluate some of these most relevant modern instruments. An outline of the project history will follow, tracing the instrument's development to its current form at the

commencement of this PhD. I will justify our choice of hardware, the *Razer Hydra* gaming controllers, and detail our custom software, including our innovative triggering system that enabled me to control velocity, sustain and release, and the MIDI Trainer function that allowed me to make mappings in *Ableton Live*. I will then give an overview of the terms used in new instrument design and formalise my design criteria.

In ***Chapter 3: Methodology,*** I will revisit my research questions and justify the methods used in this self-reflective, artistic, practice-based research. All these terms will be defined within this chapter as I also explore the notions of reflecting-on and reflecting-in action. Lastly, I will touch on the artist/engineer relationship between Mark Havryliv and me, and our integration of some methods from action research into our iterative design process.

In ***Chapter 4: Case Studies,*** I will describe some of the pivotal projects that involved the AirSticks throughout this PhD and provide links to dozens of documented performances. The observations, gathered mostly from journal entries but also from reviews of performances and interviews with collaborators, will be presented through descriptions of these projects that I was involved in, detailing some emerging and recurring concepts of instrument design. I will also discuss what I refer to as 'the one-person band dilemma' in the design of a new instrument for ensemble playing. Much work needs to be done in solitude in the early stages of the development of an instrument, and it is important to make sure that this does not affect the overall goal of creating an instrument for ensemble playing.

In ***Chapter 5: Discussion,*** I will address the research questions through an in-depth discussion of these concepts of instrument design, including metaphor, magic and illusion, and outline several approaches to tackling the mapping problem through these concepts. I will refer to these approaches, or entry points into the mapping process, as sound-first mapping, movement-first mapping, genre-specific mapping and mapping for an ensemble, and elaborate on them throughout the chapter.

In ***Chapter 6: Future Work,*** I will outline the development of new software and ideas for future hardware. I will also touch on making the shift from designing an instrument for my own personal use to that of other artists. I will then conclude this thesis with some final thoughts on my latest projects and the AirSticks' influence on my drumming practice. ***Chapter 7: Conclusion*** will be a brief and concise summary of this thesis.

I will now give a background to the development of the AirSticks, both from my own personal narrative and the wider narrative of instrument design.

Chapter 2:

Background

2.1 Introduction

This chapter is split into five sections. In the first section I will recall my own developments as a musician who has worked professionally as a **drummer** and an **electronic music producer** (in the forms of composition and sound design), culminating in the development of a new instrument to combine these two skills. I will then give a very brief history of **acoustic and electronic percussion,** ending the section with a more detailed outline of gestural or **open-air controllers** (Rovan & Hayward 2000). The **project history** of this new instrument will then be described in the third section, followed by an outline of the **current hardware and software** used throughout the project. In all of these sections I will reference the **design criteria** of several instrument designers in creating my own design criteria or informal hypothesis. The chapter will close with a glossary of some important terms within the field of **instrument design**. It is worth noting that my state of the art review is woven throughout these sections below but also in Chapter 5: Discussion later on.

2.2 Artist's Background

2.2.1 The Drum Kit – its Limitations & Explorations

My primary instrument is the drum kit, and like many instrumentalists I have 'an "emotional" affection towards [this]… instrument' (Magnusson & Mendieta 2007, p.94). I have always loved the four-limb approach that must be taken with the instrument. It makes me feel like I have to be dancing to play it properly. Since there is no way of utilising conventional harmony, melody or note duration on the drum kit, the instrument begs the musician to explore rhythm and timbre to the highest degree. This connection between movement and sound, and the exploration of hitting, caressing, rubbing, kicking and stroking different surfaces with different held objects, are of the greatest importance in attaining virtuosity.

The drum kit is also inherently adaptable. Though the standard kick, snare, hi-hat, crash, ride and toms create a lifetime of exploration, cowbells, bells, woodblocks, shells, wheels, belts, coins, anything imaginable can become part of the kit. Even in the most experimental of improvised music, this element of deriving sounds from any material can spark interest in the more conservative audiences. 'A childlike fascination with the meticulous exploration of the sonic potential of 'things,' musical or otherwise, driven by the pleasure principle, is also common in much experimental improvised music' (Arias 2002, p.31).

Audiences can also feel a great connection with the large movements often needed to play the drums. This style of big arena rock head-banging exhibitionist drumming, however, is not the most efficient way to play the drums. As much as I have enjoyed hamming up playing the drum kit when the situation calls for it, I get greater enjoyment minimising my movements on the drums; to glide over them. This more intimate and sensual experience with the instrument leads to more intimate and sensual experiences for the audiences in smaller venues, and to a greater attention to the sound itself.

The drum kit, being a relatively new instrument, has entwined itself with the recent history of popular music. Popular styles of music from jazz, funk, rock, metal, pop, surf, disco and latin all have their characteristic drum grooves. The drum kit has become such a staple of modern music that even electronic dance music, a genre often made completely on a computer with no drum kit in any physical form whatsoever, utilises these grooves originally played on the acoustic kit. Electronic dance music, based around the sounds of the *Roland 808*[1]*, 909*[2] and other synthetic and sampled kit sounds, has split off into numerous incredibly specific genres. As a professional drummer, it is essential to understand the nuances of all these styles of music, whether acoustic or electronic. Sheet music is not often handed to drummers as we are expected to know how to play these different styles. Drummers must rely on their listening skills, and feel through a piece of music, referencing the conventions of the genre that best fit the music.

Drummers are also particular good at incorporating rhythms from other percussive

[1] For more visit https://www.rolandcorp.com.au/blog/tr-808-drum-machine-flashback
[2] For more visit http://mixmag.net/feature/909-tracks-using-the-tr-909

instruments to the drum kit. The best example of this can be found in modern latin jazz, where rhythms that were once played across several simple percussion instruments are now played by one drummer on a kit. A more specific modern example is Simon Barker[3] taking traditional Korean drumming and incorporating it into his jazz improvisations in extremely evoking and fluid ways (Barker 2015).

Similarly, drummers have reacted to the rise of electronic music by mimicking rhythms produced on computers. These looped rhythms, originally sampled from acoustic drummers, form the essence of electronic dance music. The conversation back and forth between drummers and electronic producers has led to several new genres of music such as hip hop, acid jazz and the more obscure folktronica[4] and wonky beat,[5] as the conversation continues and new genres emerge. Now most of these genres are so far removed from the original drum samples that they are impossible to represent through an acoustic kit. And the rise of live electronic percussion in the form of electronic pads has left a lot to be desired.

I personally have had a fascination with all the elements of drumming discussed here. I have played extensively with a masked band, *Darth Vegas,*[6] whose genre hopping music allowed me to notice the subtleties between ska, surf, polka, funk and swing. Also, performing in this band while wearing a mask made me play all these genres with dramatically different body posture, attempting to embody the middle-aged surf rocker for one moment, the angry metal drummer the next, and the sleazy jazz drummer a moment later.

Darth Vegas led me to playing in all sorts of theatre shows starting with *Circus Monoxide*.[7] The circus taught me to watch performers intently for cues and marking, and to always be 'on'. The reaction of the band to various performers had to be part of the picture. As a circus drummer, I needed big gestures and big faces to reach and communicate with the child-friendly audiences.

The circus led me to other theatre productions, culminating in a two-year, 417 show tour of Australia with *Keating! the Musical*.[8] This musical featured a five-piece band which were always on view to the audience. Again, we were always part of the picture, and again genres as diverse as power ballads and mambos were part of the repertoire. Embodying these genres and communicating the emotions of the show through our physicality on our instruments was a point of pride for the band. How can an instrument be played triumphantly when our hero needs support, or sorrowfully when all hope is gone?

At the same time as being concerned with ways of playing different genres and performing them in the most suitable fashion for the different musical situations, I was also exploring how to combine and bend genres in different ways. My main project for this was

[3] For a video of a lecture by Simon Barker on his drumming practice visit https://youtu.be/gz6uHO2XstQ
[4] For more visit https://web.archive.org/web/20110615061923/http://entertainment.timesonline.co.uk/tol/arts_and_entertainment/music/article5597809.ece
[5] For more visit https://pitchfork.com/features/grime-dubstep/6840-grime-dubstep/
[6] For more visit http://www.darthvegas.com/vid3o.html
[7] For more visit https://youtu.be/N4ND8qbdTTM
[8] For more visit https://www.theage.com.au/news/arts-reviews/keating/2007/04/02/1175366118223.html

Gauche,[9] a five-piece band that combined influences as diverse as *Portishead, Astor Piazzolla, Radiohead, John Barry, Mum, Cinematic Orchestra, Billie Holiday, Bjork, Amon Tobin* and *Aphex Twin* in a way that ideally didn't resemble any of them. I wrote many of the tunes for this band, and the tunes I brought in were always the least complete. I wanted my compositional ideas to go through what we called the '*Gauche* filter' – the combined aesthetic of all the members of the band, and for them to bring their own individuality and story to each tune. I never believed in telling musicians exactly what to play in a band situation. I would create demos of relatively poor quality on the computer, in a sense freeing myself of any aesthetic decisions. Having constructed the drum parts on a grid through a MIDI computer graphical interface, I spent a lot of time learning how to play these parts on a drum kit, as they never came naturally. I really enjoyed this process of playing unintuitive drum parts and making them feel comfortable on the drum kit, comfortable enough to improvise around. It has always been part of my drum practice to play as many combinations of rhythms between the hands and feet, so doing this in a creative way was very satisfying, and these once uncomfortable drum parts would seep into my open improvised playing. Sometimes I also needed to augment the sound of the kit to get the sound I was looking for in these drum parts. I would need to put a set of keys on the snare, or a small cymbal on a floor tom, or a towel on a cymbal. Other times I simply could not get the sound I wanted from the kit itself and had to explore electronic means.

This led me to an exploration of sound beyond that of the acoustic kit and into the world of electronic music, firstly through the means of contact mics, pedals, field recordings and no input mixers, and later the exploration of the computer as a tool for production, performance and improvisation, not just demoing.

2.2.2 Electronic Music – Endless Possibilities

There is a long tradition of percussionists being 'attracted to the use of electronics' (Bailey 1993, p.100). Being naturally inclined to explore all possible acoustic sounds, it makes sense to also want to explore electronic sounds. My earliest non-acoustic sonic explorations were purely electronic, consistently avoiding the use of computers in attempting to find a 'voice' in the Sydney experimental improvised music scene through performances at the *NOW now,*[10] and with the *Splinter Orchestra.*[11] This intention to find a voice, personal narrative or telling of one's own story is one of the most important aspects of improvisation, particularly improvisation of the American tradition (Lewis 1996). This is a central theme of this thesis and summed up beautifully by jazz drummer Art Taylor below.

'If you take up an instrument, I don't care how much you love somebody, how much you would like to pattern yourself after them, you should still give yourself a chance to find out what

[9] For more visit https://gauche-aus.bandcamp.com/
[10] For more visit http://www.thenownow.net/
[11] For a video visit https://vimeo.com/156369505

you've got and let that out.' (quoted in Taylor 1993, p.97)

At this early stage of my development in searching for new ways of telling my personal narrative through my music, I was looking for a tactile and real-time response to bounce sonic ideas off other musicians telling their stories in the group improvisations. For me, this came in the form of a no input mixer and a bunch of contact mics on bits of junk percussion which could be played in several ways with various sticks, mallets and brushes, and be amplified and put through hardware effects. Shifting these effects in real-time was essential for me, and effects units like the *Korg Kaoss Pad*[12] provided some expression with one hand. I named this instrument the *Electro-Acoustic Percussive Pad*[13] (EAPP) and regularly improvised with it. I also used it in *Gauche* both live and in the studio. I yearned to design an interface that would allow the manipulation of sound without interfering with the four-limbed approach of playing the drums. This came in the form of a hat, designed by composer and computer programmer, Mark Havryliv, which could track my head movements and convert them, through a computer, to change parameters of an external effects unit. I performed with this hat seldom, as it required a lot of setting up and the head movements needed to perform with it were not comfortable to make or pleasing to watch. The hat quickly lost its place in my live setup.

Also, much of the music that I was listening to, that I was inspired by, came in the form of computer music; a sound far more sonically advanced than what I was creating live. Recording improvised music sets on minidisc recorders left a lot to be desired, and studios were expensive to hire. I tackled my fear of computer music, locked myself away, and produced an EP called "*Ideophone"* under the alias of *Foley.*[14] "*Ideophone"* had little rhythmic complexity but the rawness of minidisc field recordings of various trips around Sydney, combined with simple electronic melodies and morphing sounds, made me feel that I had created something a lot closer to what I desired as a composer. However, this EP was impossible to recreate live.

The use of computers to explore rhythmic complexities then emerged, as I forged a collaboration with electronic producer, Greg Seiler aka *Comatone,*[15] whose great strength was utilising his computer as a music-making tool or instrument. Compositionally, I had reached a new level of satisfaction with this collaboration, which combined household sounds, synths, morphing cross-rhythms, Escher concepts, sci-fi film scores and an acoustic kit. Our debut album was reviewed positively in the small Australian independent electronic music scene. [16] We performed live a few times, but could not come close to recreating the intricacies of the album live without a backing track. I attempted to put together a live show, cutting the album up into as many small one-shot samples as possible and having a band learn all the parts on various synths and triggers. Unfortunately, we did not have the technology to create the desired

[12] For more visit http://www.korg.com/au/products/dj/kaoss_pad_kp3_plus/
[13] To hear the *EAPP* featured in *"Honeymoon"* visit https://gauche-aus.bandcamp.com/track/honeymoon
[14] To hear *Foley* visit https://myspace.com/foleysound
[15] To hear Comatone & Foley visit https://comatoneandfoley.bandcamp.com/
[16] For a review of this collaboration visit http://polaroidsofandroids.com/reviews/comatone-and-foley-trigger-happy/166.html

live performance. The music was simply too complex and layered to perform with just synths and triggers as much of the expressive nature of the music came from automations and manipulations of various parameters of individual sounds. I did want to promote this album through live performance but the greater desire was forming a band that would sound like an electronic producer; one that could make similar compositional and aesthetic decisions to an electronic producer but be free to improvise around themes and rhythmic structures and in turn be something completely different to either an electronic producer or a live band.

2.2.3 A New Instrument Emerges

Mark Havryliv and I took our ideas from creating the hat controller a step further. I began to think of the possibilities of playing electronic percussion in the air, slashing and swiping about and controlling every nuance of the triggered sounds by turning and twisting the body, using 'AirSticks.' Before this project formalised in the form of this PhD at the beginning of 2013, Mark and I went through a series of informal trials and prototypes in attempting to build this instrument. Mark felt confident that with the right hardware, he could design software that would allow me to:

- build on my drum practice incorporating all four limbs;
- trigger and manipulate sounds in a 3D playing space using hand and finger movements;
- access a plethora of mapping possibilities in a software music sequencer and digital audio workstation, *Ableton Live*[17], through the design of a MIDI Trainer function; and
- create a physically plausible connection between movement and sound which could in turn be communicated to the audience and to other musicians in an ensemble.

These informal design criteria emerged out of my creative practice and led to the pursuit of three initial research questions upon the commencement of this PhD. A fourth research question also emerged as the project developed.

[17] For more visit https://www.ableton.com/en/live/

Question 1

What are some effective ways to utilise the existing motor skills of expert drummers in designing a truly new instrument?

Question 2

What are some effective ways to utilise the latest in motion capture technology in the design of a new instrument that can be used not only to perform electronic music, but also as a tool for improvisation and composition within an ensemble?

Question 3

What ways are there to facilitate more satisfying collaborations between electronic musicians and acoustic musicians, visual artists and physical performers without technology hindering the creative process?

Question 4

What are some effective ways of overcoming creative paralysis in tackling the mapping problem?

Now that I have outlined my own narrative and journey towards this formal research, I want to summarise the history of percussion and the emergence of the use of open-air controllers in the design of electronic percussion instruments.

2.3 History of Percussion

In this section I will outline the development of **percussive instruments** from their origins in primitive times and relationship to dance, to the invention of the **drum kit**, through to the introduction of **electronic percussion**, particularly in the form of **open-air controllers**. I will then give examples of these open-air controllers and compare them to the more conventional electronic percussive pads.

2.3.1 Early Percussion

The origins of percussion stem back to the earliest concepts of human music making, when primitive humans utilised foot stomping and hand clapping to create a regular pulse (Blades 1992). These movements were then translated to the striking of the simplest of gathered materials. 'The most important functions of the early percussion instruments were to assist the dance and to serve primitive magic and ritual' (Blades 1992, p.35). One reason for the longevity of these early instruments is their inherent ability to make the audience appreciate the link between the physical movement and sound created (Aimi 2002). The short attack of percussive instruments separates them in this way from instruments that require blowing or bowing, making them the most transparent instruments in the world. As percussive instruments made their way into music from all over the world, their flexibility grew, and percussionists began to become more specialised at their instrument. Percussionists began to play more than one simple percussive instrument at a time. With a 'low entry fee' (Wessel & Wright 2002, p.1), these musicians elevated the ceiling on virtuosity by making use of all four limbs. The earliest recorded example of a drummer incorporating his feet into playing percussive instruments through the use of a mechanism that allowed a beater to hit a drum is that of William Ludwig (Aldridge 1994). In 1909 the Chicago-based drummer patented the design of the *bass drum pedal,*[18] which allowed percussionists to play rhythmic patterns with the feet while maintaining the freedom to play patterns with the hands. Other instruments like *cymbals*, *tom toms*, *woodblocks* and *cowbells* also started being incorporated into the setup of the drum kit, and it wasn't long before another percussive instrument played by the foot was developed: the hi-hat allowed drummers to use a pedal to bring two cymbals together for a tight bright sound. Nowadays the drum kit comes in all shapes and sizes, with some drummers utilising several foot pedals for various percussive instruments. Now expressive drummers can be found playing extremely diverse styles of music with great virtuosity all over the world.

[18] For an article on early bass drum pedals visit http://drummagazine.com/classic-the-birth-of-bass-drum-pedals/

2.3.2 Electronic Percussion

Although the invention of the earliest electronic percussion instruments like Leon Theremin's *Keyboard Electronic Timpani* date as early as the 1930s (Kent 1969), it was the modular synthesis technology of electronic pads (see Figure 1) of the 1960s that sparked a myriad of new sounding electronic percussive instruments (Aimi 2002). By connecting transducers to pads, and 'plugging the resulting waveform into a modular synthesizer, they [percussionists] could use the trigger output to gate a synthesizer sound' (Aimi 2002, p.15). These flexible instruments made it possible to perform sounds different to existing acoustic percussive instruments while maintaining a strong transparency between movement and sound. However, a great deal of expressivity and virtuosity was lost as these instruments did not maintain the subtlety inherent in striking an acoustic drum. *Synthesisers* had gained a lot of popularity in the 1960s, but they had most commonly taken the form of a keyboard interface with some knobs and sliders. Few designs incorporated electronic pads of any sort. The greatest pioneers of the *synthesiser*, Robert Moog[19] and Donald Buchla,[20] offered very different conceptions of the instrument; Buchla stressing 'uncertainty, idiosyncrasy, the "wild and wonderful…" [Moog] stressing control, reliability, and repeatability. This tension between 'machine' and 'instrument,' and between the values and norms reflected in these different conceptions, resurfaces throughout the history of the synthesizer' (Pinch and Bijsterveld 2003, p.551).

Figure 1. Kraftwerk playing early electronic drum pads.

[19] For Moog's most recent musical instruments visit https://www.moogmusic.com/
[20] For Buchla's most recent musical instruments visit https://buchla.com/

2.3.3 The Standard Modern Electronic Drum Kit

In more recent years, with the increase in speed of computers and the introduction of MIDI, electronic pads have been used to trigger samples as opposed to closing circuits, increasing the flexibility of these instruments to almost limitless domains. This has meant that any sound can be assigned to a strike of an electronic pad. Modern top-of-the-range *electronic drum kits* (see Figure 2) incorporate foot movements into their full kits and often market themselves on giving the performer ultimate control over the drum samples they trigger by allowing the editing of virtual parameters such as microphone placement, room size, drum skin tension, drum size and drum material. This culture of attempting to emulate acoustic drum kits with electronic percussion can be seen as a response to the use of close miking of drum kits in live and studio situations. Since so much of the drumming we now hear comes to us electronically, that is through speakers, these modern drum kits give the performer the experience of playing highly produced sounds. These drum kits also attempt to give the performer a more 'acoustic' experience in the way the velocity and the precise location of the strike on the surface is captured. Nowadays these pads can utilise a range of different sensors to capture movement across and into the skin surface (Tindale et al. 2005; Tindale 2007). The top of the range Roland electronic drum kit or *V-Drum*[21] allows the use of brushes on the pads. New techniques such as convolution have also been used to combine the acoustic and electronic experience of playing a percussive instrument (Aimi 2007), using **metaphor** and the existing motor skills of acoustic drummers to help them make the shift to these new instruments.

Figure 2. ***Roland V-drums*.**

[21] Arguably the most popular electronic drum is Roland's V-drums. For more information visit https://www.roland.com/au/categories/drums_percussion/v-drums_kits/

2.3.4 The MPC

Akai's Music Production Center (MPC) [22] and more recently interfaces such as *Native Instrument's Maschine*[23] and *Ableton's Push,*[24] (see Figure 3) combine smaller pads with knobs and a small screen to trigger and manipulate samples. As the name suggests, the *MPC* was originally designed to be a studio production tool, but it quickly became the staple of any hip-hop live show along with the *Turntables.*[25] Though this instrument invites the performer to play it with smaller, less transparent and expressive finger gestures than an electronic kit, it is hard to argue that there are no virtuosic performers on these instruments.[26]

Figure 3. The *MPC* (top), *Maschine* (middle) and *Ableton's Push* (bottom).

[22] For information on the latest version of the MPC visit http://www.akaipro.com/products/mpc-series
[23] For more visit https://www.native-instruments.com/en/products/maschine/
[24] For more visit https://www.ableton.com/en/push/
[25] The skill of using the turntables as a musical instrument is referred to as Turntablism. For more visit https://www.theguardian.com/music/2010/jan/11/hey-whats-that-sound-turntablism
[26] Virtuoso Jeremy Ellis https://youtu.be/HdFlFxJFnfY

Just as the modern drum kit developed from simple percussion, new more complicated instruments that consist of more plentiful, smaller, more velocity sensitive pads have developed from the *MPC* that no doubt enable expression and virtuosity. Still, these instruments rely on the triggering of samples by hitting or pressing on pads with the hands, and leave little room for the manipulation of the triggered samples.

But perhaps the greater space for expression and virtuosity enabled by the *MPC* and similar devices is not necessarily just as a performance tool, but rather as a compositional tool, and in the reprogramming or redesigning of the instrument for different situations. 'The process of designing the instrument becomes a process of composing at the same time,' (Magnusson & Mendieta 2007, p. 97-8). These devices sped up the design and composition processes to a point where the construction of **composition can be thought of as a real-time performance in itself**. Sampling sounds, editing them, manipulating them, playing them out live, all within a performance situation. This is a concept I will elaborate on later in Chapter 5: Discussion.

It is worth noting that touchpads, in the form of smartphone and tablets, are now being utilised in similar ways to these devices, with some electronic producers giving preference to these thin, light, hand-held interactive screens.[27] *Akai* and *Native Instruments* have both created app versions of their hardware. Some designers have also started to utilise the motion sensors in these devices to convert movements to MIDI or OSC messages sent to a computer, most notably *Touch OSC*[28] (Roberts 2011). Others, such as *Auug,*[29] have designed hardware that augments the smartphone for gestural control over sound (Michon et al. 2017).

Having witnessed the evolution of percussive instruments over time, how can the technology of today be used to not only 'replace or enhance traditional percussion instruments, but enable new ways of playing music that were not possible before' (Aimi 2002, p.17)? To go beyond mere imitation of acoustic instruments? Furthermore, how can this new music be performed not only with greater transparency, but also with more expressivity than in previous electronic instruments?

[27] For some examples of music making apps for tablets and smartphones visit https://www.theguardian.com/technology/2015/oct/17/ten-of-the-best-music-making-apps-for-beginners
[28] For more visit https://hexler.net/software/touchosc
[29] For more visit http://www.auug.com/

2.4 Open-air Controllers

A small group of instrument designers in the field of electronic percussion have shifted their focus from creating more elaborate sensors for electronic pads to completely deconstructing the traditional approach to triggering sounds. These gestural instruments utilise open-air controllers to allow the performers to trigger and manipulate sounds by slashing and striking through the air and '**magically** conjure music from 'thin air'' (Rovan & Hayward 2000, p.1).

In this section I will provide some examples of instruments that utilise open-air controllers, and outline some of these instrument builders' design criteria in creating these new instruments, justifying their choice for using open-air controllers as opposed to controllers with more conventional sensors. I will then outline some of the challenges these designers face in utilising open-air controllers as a musical interface and discuss ways these challenges are being negotiated.

2.4.1 Examples of Open-air Controllers

In this section I will outline some open-air controllers for music making. There are many other controllers worth mentioning, but for the purposes of this thesis I will only discuss the following due to their relevance to percussion, their popularity or historical significance.

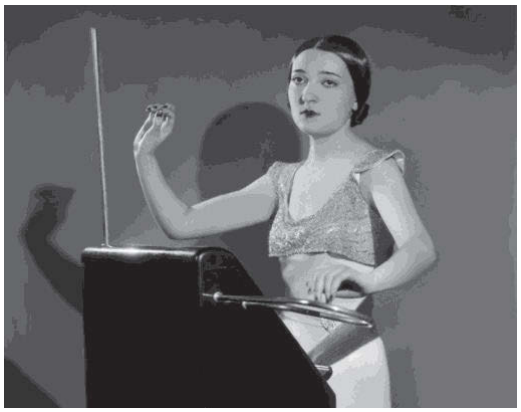


Figure 4. The *Theremin*, played by Clara Rockmore.

Photo by Renato Toppo. Courtesy of the Nadia Reisenberg – Clara Rockmore Foundation

The Theremin

The concept of open-air controllers still most famously invokes images and sounds of the *Theremin* (see Figure 4). The reason for its success is possibly due to how well-defined and confined the instrument was (Ostertag 2002). Clara Rockmore[30] was arguably one of the very few virtuosos of any open-air instrument, perhaps even of any electronic instrument, dedicating herself to mastering this most difficult of instruments. Unlike modern interfaces, the *Theremin* has a distinct sound and a fixed way of being played. It is not a flexible instrument and does not

[30] For footage of a performance visit https://youtu.be/pSzTPGlNa5U

pretend to be so. These characteristics of the *Theremin,* however, are also its downfall. 'The main problems with the Theremin, played by moving the hands between two antennas, were its limited timbral range and the difficulties of learning to control an instrument that offered no physical feedback at all' (Pinch and Bijsterveld 2003, p.544).

Figure 5. The *Radio Baton*, demonstrated by Max Mathews.

Mathews/Boie's Radio Baton

The *Mathews/Boie Radio Baton* (see Figure 5) is one of the earliest examples of an open-air controller for percussionists. Developed in the late 1980s, the interface's fortunate relationship with the visual programming language, Max/MSP,[31] developed around the same time by Miller Puckette, allowed musicians such as Andrew Schloss[32] to convert physical movement, in the form of data from the *Radio Baton*, into sound. This allowed him to capture not only information from a sound trigger, but also that of the movement of the sticks before and after a strike. The *Radio Baton* captures movements using five antenna receivers in an array on a board placed below the mallets held by the performer (Boulanger 1997). Each of these mallets includes radio transmitters on its tip, which sends information at 50Hz to the antennas, five times slower than many modern open-air controllers. The *Radio Baton* sends a MIDI note-on message when a mallet crosses an invisible plane above the antenna board. Boulanger calls this plane the hit-level. A second plane, called the set-level, is positioned just above the hit-level. This plane acts as a note-off trigger to avoid double triggering. As well as generating note-on triggers, this instrument also captures and sends xyz position data. Schloss (1990) uses all this data to allow three levels of control: a timbral level, a note level and the control of a musical process. It is this control of a musical process that gives the electronic percussionist greater control over musical expression than can be gained from a two-dimensional surface. Since the computer is constantly receiving xyz position data, control changes can be made at all times, giving the performer of the *Radio Baton* extra control and expressivity. The *Radio Baton* as a controller has also been utilised within other new instruments, such as the *Thimbal* (Bresin, Hansen & Dahl 2003). The downfall of this relatively unknown instrument may be due to its limited usage and small performance space. It was mostly mapped by its designer to control

[31] For more visit https://cycling74.com/products/max/
[32] For footage of a performance visit https://youtu.be/bVg7zlOyyOw

MIDI classical scores using the metaphor of a conductor,[33] which didn't seem to inspire much use from other players.

Buchla Lightning

Buchla Lightning (see Figure 6), like the *Radio Baton*, also tracks a percussionist's movement, though the *Lightning's* range is much larger (Rich 1996). This interface uses infrared lights on the tips of the sticks to track movements and also comes with a receiver box and sound module which holds a large number of in-built sounds, a variety of patches that respond to gestures in different ways, and various other user-friendly functions. It was designed and marketed for mass production without much success, merely adding to the array of innovative electronic instruments of Don Buchla. Seemingly the most expressive open-air controller, spearheaded by *Lightning* virtuoso Joel Davel,[34] this instrument's failure is difficult to identify. Price point may be one factor, though more likely the sounds that come with the instrument are its undoing. Being a MIDI controller these sounds could be easily replaced, but first impressions of the sound of an instrument can be hard to change.

Figure 6. ***Buchla Lightning*.**

Mi.Mu Gloves

Since the creation of these gestural controllers reviewed above, several percussionists, other musicians and composers have explored new ways of converting movement into digital information that can then be converted into sound. One popular way of tracking a performer's movements has been the use of gloves. Though not the first to use gloves as open-air controllers, both Waisvisz[35] (1999) and Sonami[36] (Jessop 2009) created similar instruments over 20 years ago, singer/songwriter and multi-instrumentalist Imogen Heap and her team designed what are now one of the most popular of gestural instruments, even though they have yet to be properly commercialised. The *Mi.Mu Gloves* (see Figure 7) are very much designed to

[33] For an interview and demonstration visit https://youtu.be/mTgJFxZXZJw
[34] For footage of a performance visit https://youtu.be/-2juR1usQUQ
[35] For footage of a performance visit https://youtu.be/pYfRORkuPX8
[36] For footage of a performance visit https://youtu.be/ngygk20M1pI

the specifications of Heap's performances as a singer and multi-instrumentalist, allowing her to loop and manipulate her voice and acoustic instruments such as the piano.[37]

Of most interest to the topic of electronic percussion is the gloves' use of 'segmented threshold triggering… Using inspection of the rotation matrix, a bass drum could be triggered when the peak is detected if the hand points downwards, a snare drum selected if the hand points forwards and a high hat selected if the hand points upwards' (Mitchell, Madgwick & Heap 2012, p.3). This is a very different use of the sensor information to the *Radio Baton*. This could be due to the data gloves giving information more quickly than the older technologies but also due to the fact that the *Mi.Mu Gloves* do not track absolute xyz position, hence the designers have had to use rotation data in more novel ways.

Heap's team has written several publications about the technology and design criteria of the *Mi.Mu Gloves*. Below are the criteria for the design of the instrument set out by Heap and her team.

- *'The musical processes should be controlled without having to defer performativity to engage in machine interaction,*
- *There should be a transparent mapping between the input to the gestural controller and the outgoing musical events,*
- *Instrumental virtuosity should be compromised as little as possible'* (Mitchell 2011, p.466).

Figure 7. Imogen Heap wearing the *Mi.Mu gloves.*

Mitchell et al. (2011) elaborate on their concept of transparency by comparing acoustic and electronic instruments. They argue that electronic music, particularly computer-based electronic music, has caused a severance between a performer's movements and the sound produced, 'that is, the transparency of the mapping between the input to an instrument/device and its corresponding output' (Mitchell 2011, p.465) is inherently lacking. They further argue that this mapping must be clear and that electronic instruments should preserve the relationship between movement and sound inherent in acoustic instruments.

[37] For footage of a demonstration and performance visit https://youtu.be/7oeEQhOmGpg

One of the key features of this instrument is the use of posture, the static form of gesture, to control the changing of functions. For example, to switch on a distortion effect, the devil's horns rock hand posture is used. To pan sound to the left or right, the performer points to one side or another. Sampling of the voice is done with a posture of the thumb and forefinger seemingly grabbing the sound from the performer's mouth. The gesture of then moving away from the mouth is used to play the sample through **granular synthesis** on a virtual timeline.

The Aerodrums

The *Aerodrums* (see Figure 8) are one of the most recent open-air controllers to hit the market and superficially the closest in design to the AirSticks. There is close to no academic writing on this product. The *Aerodrums* are mallets tracked by a camera, similar to the *Lightning*, which allow the playing of acoustic drum samples in the air. When a mallet is used this way, that is in not hitting a surface of a drum, the back of the mallet naturally hits the palm of the performer's hand. The *Aerodrums* designers took this simple physical phenomenon of using the palm as a natural trigger surface to detect a sudden stop, and hence a trigger, through the use of high speed modern cameras.[38] The designers have focused on creating a product that feels and sounds very much like a drum kit. In this way, this instrument is simply an impressive gimmick that allows drummers to practice quietly without carrying electronic pads. A similar degree of expression to using an electronic pad is attained through the *Aerodrums*, enabling the control of some velocity, but not utilising the information of the movement through the air in any significant way beyond the strike.

Figure 8. The Aerodrums.

[38] For a video on the way the *Aerodrums* utilise traditional drumming technique visit https://youtu.be/iF8296Aai9k

A similar product to this, *Freedrum*, (see Figure 9) has also recently been developed. *Freedrum* uses some sensors on a standard drumstick to allow the triggering of different drum sounds in a virtual **playing space**, but again, does little more than emulate an acoustic (or electronic) drum kit for quiet playing.[39] Also of note is a new gestural shaker instrument for sound synthesis, *bEADS* (Williams & Overholt 2017).

Figure 9. Freedrum.

All these instruments have a specific range and personality, and with using them come certain opportunities and challenges which I will now outline.

2.4.2 Reasons for Utilising Open-air Controllers

So as can be seen from these examples, open-air controllers 'unchain the performer from the physical constraints of holding, touching, and manipulating an instrument' (Rovan & Hayward 2000, p.1). They also enable:

- the control of sounds before and after a strike – this can lead to a more **expressive** and **intimate** instrument with the percussionist having more ways to control the sound they trigger (Schloss 1990);
- the lowering of perceived computer latency and **controllability** – as there is no physical contact with a pad, the percussionist has no sense of the time lag between a strike being made and the sound being heard (Malloch et al. 2011);
- movements to be better assigned to represent the sound – **(transparency)** a better visual representation of sound through movement can be attained as all movements, not just a striking of a surface, can be assigned to a change in sound;
- quietest playing, no sound made by a stick hitting a pad **(expression)** (Schloss 1990).
- lightest and most compact setup, no need for pads.

[39] For a video visit https://youtu.be/_wlnMCr91Ds

2.4.3 Challenges in Using Open-air Controllers

Below are some challenges that instrument designers, who use these controllers, face. Some current solutions for these challenges are included here, and more will be presented in Chapter 6: Future Work.

- No **haptic** response – many instrument researchers have discovered that musicians need **haptic** or **tactile** feedback from their instruments in order to be comfortable in playing it consistently (Havryliv, Naghdy & Schiemer 2012; O'Modhrain & Adviser-Chafe 2001). To get around this problem some instrument designers have incorporated vibration sensors or swing mechanisms and/or the use of audio feedback in the design of their open-air controllers (Berdahl, Niemeyer & Smith 2009; Chafe 1993; Florens et al. 2004; Ilsar, Havryliv & Johnston 2013).
- No stick response – percussionists often rely on the physical response of a stick or pedal on a surface to help them play faster and more accurately. One way of compensating for this is to allow the triggering of sounds both down and up through a virtual plane, using the metaphor of a shaker or the strumming of a guitar, to facilitate faster note retriggers (Ilsar, Havryliv & Johnston 2013).
- Difficulty knowing precise position – as with any instrument, practice is essential for attaining virtuosity. It is particularly difficult to learn an instrument such as the *Theremin,* where there are no reference points like frets or even a finger board (Pinch & Bijsterveld 2003). A way of getting around this is allowing the computer to create virtual frets or boxes that make it easier to be accurate. The use of the visualisation of tracking motion onto a screen can also help percussionists to learn the subtleties of instruments incorporating open-air controllers (Ilsar, Havryliv & Johnston 2013), as can different forms of **haptic feedback** such as vibration sensors.

Open-air controllers come in many shapes and sizes and can be very well integrated into the instrument as a whole: that is the mapping and any software developed. When we first had the idea to create the AirSticks we did our research in trying to find existing open-air controllers or indeed a complete gestural instrument that could meet our design criteria. Not even the newer controllers listed were usable for us as will be explained in the following section. In the next section, I will outline our search for our own open-air controller and the shifting of our informal design criteria into a more formalised one at the commencement of this research project.

2.5 Project History

In this section I will outline the two different hardware prototypes of the AirSticks that eventually led to the current hardware and software used in the project.

In 2003, I began a collaboration with composer, musician and software engineer Mark Havryliv. Just before embarking on this project, Mark had designed a jacket he used to manipulate the sound of other musicians in his own live performance situations (Schiemer & Havryliv 2004). The jacket used mercury tilt sensors that enabled him, with the movement of his arms, to change the parameters of a patch built in *Pure Data*, a similar piece of software to *Max/MSP*, as audio from the live musicians was routed to his computer. Mark designed a similar wearable item for me, in the form of a hat. In my live setup, I replaced the use of the *Korg Kaoss Touchpad* that took my right hand away from playing rhythms, with this hat. This allowed me to play electronic pads with all four limbs and still be able to manipulate sounds through simple head movements. We decided that instead of using tilt sensors, head movements would be more conveniently captured using an accelerometer sewn into a hat worn by the performer. This hat acts as a tilt sensor capturing x- and y-rotation. We decided to not utilise this hat device shortly after including it in my live setup, as it seemed like a very unnatural part of the body to control sounds with.

The use of accelerometers did inspire us to rethink our system. Instead of hitting an electronic pad and manipulating effects with the head, or the torso, knees or elbows, or any other body part that may be moved separately to the striking of a drum with the arms or legs, why not manipulate effects with the same action as the strike? The idea of triggering samples by slashing through the air greatly excited us, not only because of the possibilities that may open up in the future by having the movement of the arms constantly tracked, but also as an aesthetic of magically creating sounds from thin air in the image of futuristic sci-fi instruments. Indeed, the AirSticks have been referred to as 'future freaky'[40] and 'the future of drumming.'[41] This search for the instrument of the future led us to explore three different technologies for designing an open-air controller.

2.5.1 Infrared & Cameras

We firstly experimented with infrared tracking by placing four infrared LED lights on the end of a mallet forming a square shape (see Figure 10). This is based on technology developed by Juno Kim (Kim, Schiemer & Narushima 2007). An infrared camera connected to the computer tracked these four lights, and according to the size and shape created, the appropriate information would be sent to another software to provide the xyz position and limited rotation data. Some of the problems with this technology were:

- A suitable lighting environment may not always be available; a device that could be

[40] From online review at http://thebrag.com/kirin-j-callinan-aurora-spiegeltent
[41] Informal discussion with former drum teacher having seen an AirSticks performance for the first time

used in the standard club, pub or concert hall was desired.

- The LED lights had to always be in the camera's vision.
- Though the latency was relatively low (10msec), after processing, it was not low enough to enable me to feel confident that a sound would be triggered at the precise moment I expected.

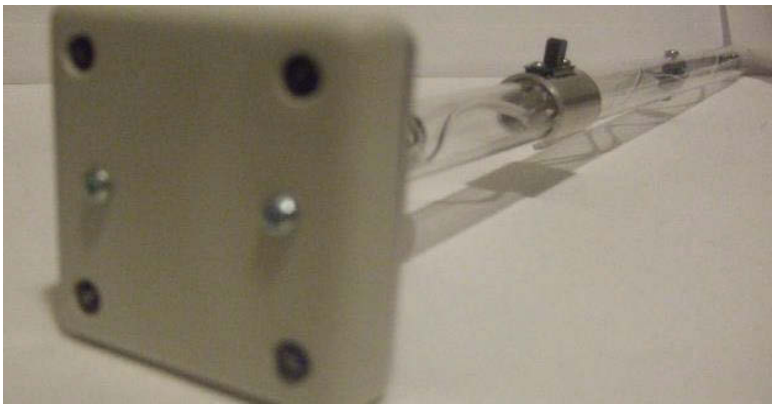


Figure 10. The AirSticks Prototype No 1. Photo by Juno Kim.

2.5.2 Exoskeleton

We then explored the idea of using an exoskeleton. The exoskeleton took information from the rotation of different joints – the shoulder, elbow and wrist – to track the location of the hands (Collins et al. 2010). After attempting to build an exoskeleton, we decided to trial the *Gypsy 6 Suit*[42] (see Figure 11) which also came with its own MIDI Graphical User Interface (see Figure 12). Some of the problems with this interface were:

- The six sensors on each arm did not give us an exact location of the hands, meaning a hand could be in the same xyz position with different orientations of the elbow and shoulder.
- It was cumbersome to wear, restrictive to move in and unreliable.
- It needed calibrating before each performance.

Figure 11. The *Gypsy 6 Suit*.

[42] For a video showing the capabilities of the *Gypsy Suit* for music making visit https://youtu.be/2Xd1L-ucZkQ

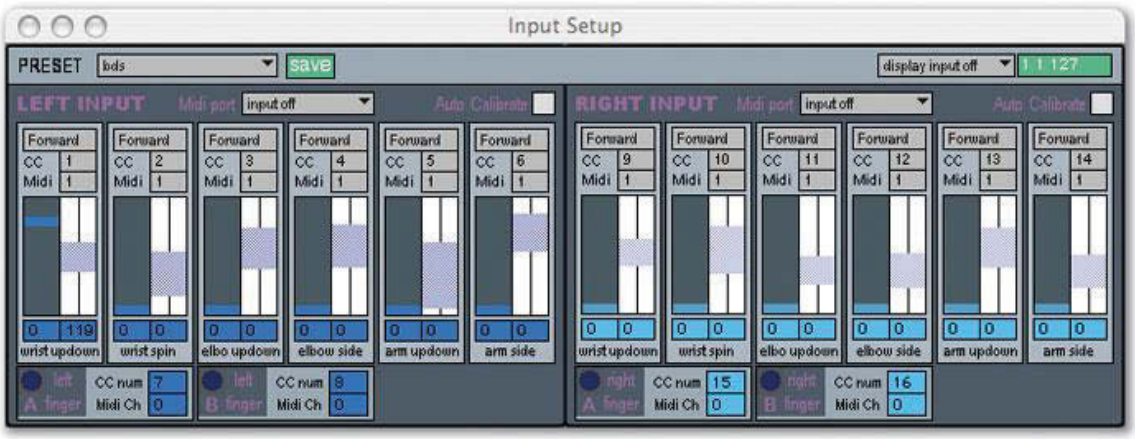


Figure 12. The *Gypsy 6 Suit* Graphical User Interface.

2.5.3 Gaming Controllers

After being dissatisfied with infrared cameras and exoskeletons for this project, we experimented with the *Razer Hydra*[43] gaming controllers (see Figure 13), which comprise of two joysticks tethered to a base station connected to a computer using USB.

The joysticks can be moved freely in space (so far as the tethering cables permit) and their position and orientation is determined by their relationship to a sphere on the base station through the use of an electro-magnetic sensing system. The device has a sampling rate of 250 Hz, with measurement precision to the millimetre and degree for position and orientation, respectively. These controllers are cheap, and an open source gaming community had already developed online with members releasing MIDI software which we began to experiment with.[44] These controllers also come with an SDK; a set of *C++* APIs which allow the developer to read the state of the motion controllers. The state comprises position and orientation, or six Degrees of Freedom (6-DOF), and the button states. The *Custom AirSticks MIDI Software (CAMS),* in the form of an OSX application, was developed based on this SDK which translates the user's movements to a graphical representation. This software will be outlined in the next section.

Other advantages such as weight, ease of setup, low-to-no interference and extra buttons for control meant that we could commit to designing a new triggering system with these controllers (Pardue & McPherson 2013; Basu et al. 2012). Another advantage of these controllers, being originally designed for video games, is that many people are very familiar and comfortable with them. Hours and hours are spent holding these types of controllers and making repetitive movements with them analogous to practicing a traditional instrument.

[43] For more information visit http://sixense.com/razerhydra-3
[44] For a video of an early musical use of the *Razer Hydras* visit https://youtu.be/7g_JE_v5CMM

Figure 13. The *Razer Hydra* gaming controllers.

With the discovery of the *Razer Hydra* gaming controllers we could finally move forward to designing software to integrate with the controllers and explore hardware to enable the triggering of samples with the feet. In the next section, I will elaborate on the triggering system we designed and the steps we took in developing a working prototype reliable enough for live performance.

2.6 Current Hardware & Software

In this section I will elaborate further on the way the *Razer Hydra* gaming controllers have been utilised in the design of the AirSticks, with a particular focus on the development of a reliable triggering system within the *Custom AirSticks MIDI Software (CAMS)*. I will demonstrate this triggering system and positive ramifications of discovering it in a series of short videos. I will also introduce the *SoftStep Foot MIDI Controller* as our chosen hardware device involving the feet in the playing of the AirSticks and highlight the use of the *Razer Hydras'* buttons. Lastly, I will demonstrate, through further videos, the integration of *Ableton Live* and the use of the *CAMS* MIDI Trainer function in mapping my movements into sounds. Having presented the AirSticks and shown my workflow in designing new mappings, I can then go on to describe my pivotal projects after outlining my methodology in the following chapter.

2.6.1 Triggering System

Having established the *Razer Hydra* gaming controllers as our chosen open-air controller, we set out to create a triggering system that could utilise my existing motor skills as a drummer to control the triggering of sounds in a reliable, comfortable and consistent fashion.

First Attempt

At first, we attempted to take the information of velocity and acceleration to decipher which movements were intended strikes (or effective gestures) and which were simply accompanying, accidental or figurative gestures. Trigger detection was based on detecting spikes in acceleration and jerk; jerk being the time derivative of acceleration. This method was inspired by the performance gesture associated with a real drum kit. A stick would be moving downward at a reasonably constant velocity, hit the drum skin and experience a large change in velocity which was detected as a peak in acceleration. The velocity and acceleration derivatives were constantly calculated from the position data sent from the device, and when an acceleration value that exceeded a particular threshold was recorded, a trigger was detected.

This approach suffered from two issues. Firstly, in the absence of a surface to impact with, I would naturally slow down just prior to triggering. This diminished the magnitude of potential acceleration peaks. This would not be the case if the controllers were shaped differently, like the *Aerodrums* for example, where a thinner longer controller, in the form of a mallet, hits the palm of the hand when there is no surface to stop the strike. Unfortunately, we were at the mercy of the design and shape of the *Razer Hydras*.

The second issue with this triggering system was that setting a constant threshold for trigger detection from acceleration data made it difficult to detect triggers across the range of potential gestures. In lowering the threshold, intentional smaller movements would warrant a strike, but unintended jitters and shocks would also trigger a sound.

A machine learning method based on neural networks was developed to analyse velocity data alongside acceleration data, a similar approach to that recently taken by other

instrument designers (Havel & Desainte-Catherine 2004; Dahl 2014). Upon recognising a peak in acceleration data, the velocity gesture leading up to that peak was analysed to see if it matched the velocity profile of a large range of strikes that had been recorded and learned in the past. This improved the performance of the trigger-detection, but minor inconsistencies were still enough to make the triggering of sounds a frustrating and uncomfortable experience.

Second Attempt

Our breakthrough came when we realised that instead of training the technology to enable the instrument to learn what my intended movements were, I should learn how to play a consistent non-complicated triggering system. This falls in line with the findings of Magnusson & Mendieta (2007): 'many people found that an important difference in these two types of instruments [digital vs acoustic] lies in the fact that the digital instrument can be created for specific needs whereas the player has to "mould oneself" to the acoustic instrument' (Magnusson & Mendieta 2007, p.96). We devised a system of imaginary planes, similar to that of the Radio Baton, again without our knowledge of this literature or even the instrument itself, that I needed to 'mould' my playing to. Instead of having a hit-level and a set-level like in the mapping of the *Radio Baton*, the rotation set of data sent from the *Razer Hydras* was used to detect a trigger point. When my wrist passed through a particular angle of rotation on the x-axis, resembling the movement of a strike, a MIDI note-on signal would be sent. I quickly established some consistency in finding this trigger point, and could even anticipate it. Other informal participants were also relatively satisfied with the response, noting though that it did take more getting used to than they thought. An auditory response in the instrument had replaced the tactile one of the electronic pads, and further hid any latency that could be perceived from an electronic instrument with a tactile response.

The angle of the trigger point was set to different degrees depending on the height of the strike to improve the ease of playing and avoid overextending. A strike up high would use a trigger point angle close to 90 degrees, or perpendicular to the ground, whereas the lowest angle trigger points would be set to 0 degrees, or parallel to the ground, with all other trigger points in between being scaled appropriately, as if I was playing an invisible concave plane (see Figure 14). Below is a link to a short video showing this function.

Imaginary Trigger Curve VIDEO

https://youtu.be/5DLzdtOk0zI

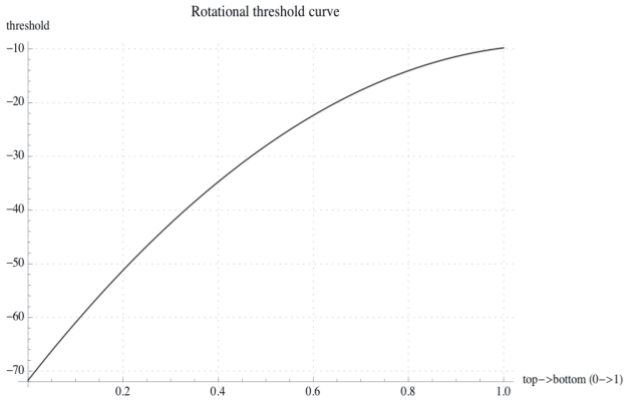


Figure 14. The threshold of the trigger angle vs the distance from the bottom of the virtual space.

Ramifications of Trigger System

There are three major positive ramifications of detecting a strike through the trigger point system as opposed to the one using velocity and acceleration. We had not anticipated these but have now attempted to take full advantage of them.

Strumming

Firstly, this triggering system enables the detection of striking down and up through the trigger point, what we call downstrokes and upstrokes, respectively. This improves the speed at which the instrument can be played utilising a 'strumming' technique of triggering sounds. This technique has not been fully incorporated into the AirSticks practice but will be revisited in the future.

Strumming Technique VIDEO

https://youtu.be/JVU0TC0mIz4

Attack and Release

Secondly, the velocity of both downstrokes and upstrokes can be used to control not only the volume and brightness of a sound, but also the **attack** and **release** of sounds. This means that a quick sharp movement up and down can create a short percussive sound, whereas a slow movement up and down can give a bowed effect.

Sustain

The third positive ramification of this triggering system is the control of note length, or **sustain**. Unlike the triggering system used in conventional drum triggers or that used in the *Aerodrums*, the AirSticks allows the control of the sustain of sounds. The electronic percussionist on an electronic pad or on the *Aerodrums* has no control over note length. In fact, note length is not often a feature of a percussion instrument. There are various ways percussion instruments overcome this shortcoming. On the snare drum, a player learns the technique of playing a roll with both hands. On the cymbal, a player can choke the sound to stop it when

desired. On the vibraphone, a sustain pedal can be used. Barring forms of extended technique, all of these systems need two limbs to work together. However, on the piano or keyboard synthesiser a note can be pressed and held with the one movement of the one hand. With the AirSticks' triggering system, keeping the wrist rotated past the trigger point holds the note on in a similar way to a keyboard. This allows the control of the sustain of sound, along with the attack and release mentioned above, much like a keyboard synthesiser, and the manipulation of this sound once it is sustained with various movements, akin to the turning of knobs and sliders on the synthesiser. To stop the sound the hand is simply moved back above the trigger point, like taking a finger off a keyboard. This discovery led us to devising numerous **sustain methods** and making several metaphors with real world physical spaces which I will elaborate on throughout the rest of this thesis.

Attack, Release and Sustain VIDEO
https://youtu.be/SY1iue20iG8

2.6.2 Thumb, Finger & Foot Movements

Having created a consistent system for capturing hand movements using the *Razer Hydra* controllers, we embarked on integrating the use of thumb and fingers movements. Like most modern gaming controllers, the *Razer Hydras* consist of a thumb joystick, a trigger button controlled with the index finger, and several buttons on each hand. This gives me the ability to send information to the computer with more subtle movements. These subtle or **discreet** movements, as I'll be referring to them throughout the rest of this thesis, are very useful as I can make them at the same time as the larger ones, giving me more nuanced control over the instrument and allowing the sending of not only MIDI 'discrete' (as opposed to continuous) changes from button presses, but also continuous controller values through the use of the spring mechanised trigger button and thumb joystick. This allows certain modes to be changed without the audience noticing, which is both a blessing and a curse as these discreet movements may improve the controllability of the instrument but reduce transparency. I will discuss this concept of discreet gestures in more detail in Chapter 5: Discussion.

Figure 15. ***The SoftStep MIDI Foot Controller.***

In tandem with the *Razer Hydras*, we discovered that a suitable way to capture foot movements was with the *SoftStep Foot MIDI Controller*[45] (see Figure 15). This controller enables me to trigger up to ten MIDI note on/off messages to other music software by hitting the heel against

[45] For more information see https://www.keithmcmillen.com/products/softstep/

a chosen pad. It also allows over forty MIDI Control Change (or CC) messages to be sent through the in-built pressure sensors in the four corners of each pad. It also allows me to scroll through various program changes. This foot controller was a major improvement to the original foot triggers I used that required a conventional foot pedal for each foot and only sent one MIDI note from each. It is our intention to use motion capture technology to incorporate more nuanced control with the feet in the future, but this is beyond the scope of this thesis.

2.6.3 Custom AirSticks MIDI Software (CAMS)

As stated earlier the *Custom AirSticks MIDI Software (CAMS)* was built by Mark Havryliv. The gaming controllers interface to an application designed for Mac OSX built using the *Razer Hydra* SDK, which provides a user interface for tracking the controllers on a screen and which outputs MIDI data based on continuous position and orientation, and implements the triggering system by sending MIDI note on/off messages with an assigned velocity for both. This arrangement provides the highest possible sampling rate and fidelity from the device, which in turn permits the use of sophisticated engineering techniques to analyse motion, and provide performance-time gestural analysis and response. A predictive filtering scheme based on Kalman state estimation is used to effectively up-sample the gestural analysis system to 1kHz, well beyond the perceptual limit for the sensation of causal association between gesture and aural result (Havryliv 2012).

The Graphical User Interface (GUI) for *CAMS* (see Figure 16) allows me to see where my controllers are in relation to the hub. Two floating points represent the middle of each controller on the screen, with the screen acting as a 2D plane of xz position; moving closer to the hub in front of me moves the point up the screen. White is for the left hand and yellow is for the right. Height is unfortunately not well represented on this current GUI, though, as will be discussed shortly, a year into this project we changed a function in *CAMS* that freed me from looking at the GUI to track my movements.

CAMS sends out MIDI CC numbers from 0-127 on different CC channels. Each movement can be assigned or MIDI mapped to a parameter or group of parameters using the *CAMS* MIDI Trainer function. This function is extremely useful for mapping movements and their corresponding MIDI CC values to other music programs. Many music programs have a MIDI mapping function which allows the user to pick a parameter they want to assign to a slider or knob, and simply move or turn that slider or knob to pair it with the chosen parameter. The MIDI Trainer allows me to MIDI map the AirSticks in a similar way, choosing a parameter and then moving the appropriate slider on the GUI. This has been my main system of mapping the AirSticks, with my music software of choice being *Ableton Live*.

CAMS also implements the triggering system, sending MIDI note on/off and velocity information. As described above, MIDI note-on information containing velocity is sent when the controller passes the trigger point. This MIDI note-on remains on until the hand is lifted above the trigger point, when MIDI note-off information also containing velocity is sent. At first, we split the playing space into sixteen boxes, 4 by 2 by 2, as can be seen in Figure 16,

giving me the option to send different discrete MIDI note values depending on where the hand is positioned in the playing space. This led to me needing to watch the screen intently to make sure I was triggering in the desired box. I will refer to this function as the Single Global Trigger Function OFF, or ***Box***.

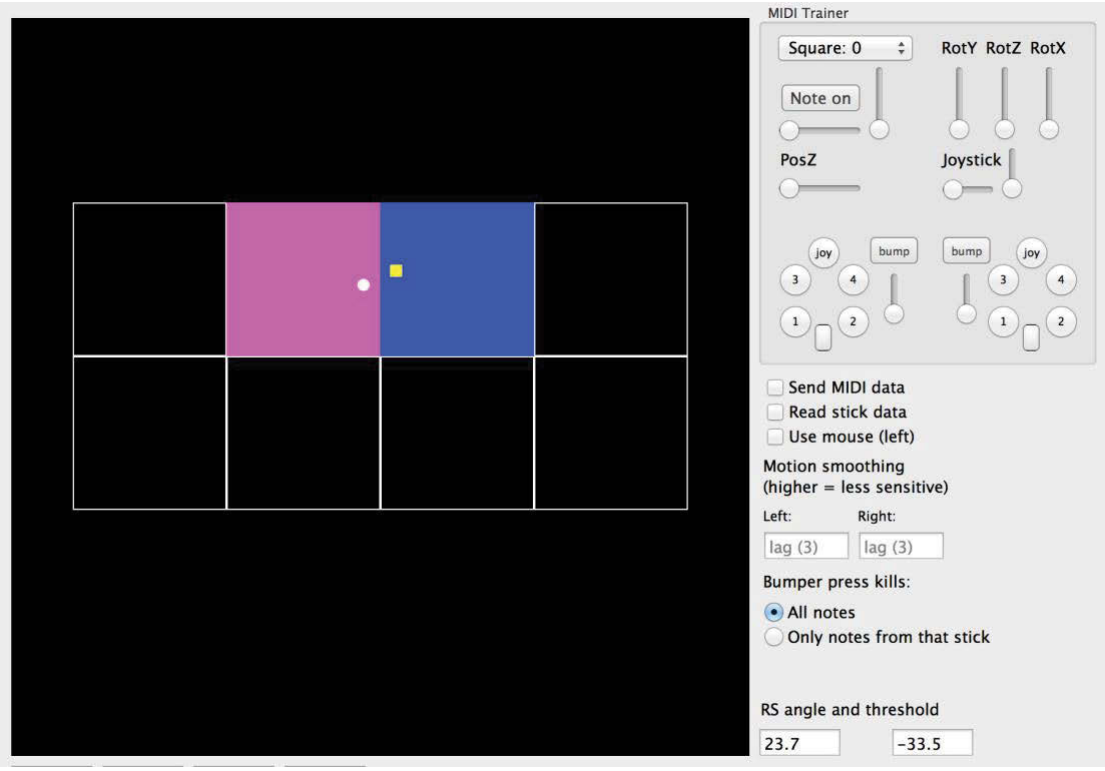


Figure 16. ***First Graphical User Interface for CAMS.***

About a year into the project we decided to change this function to what I am calling Single Global Trigger Function ON, or ***Morph***. With *Morph*, *CAMS* simply sends one MIDI note value for each hand, no matter where a strike is made. With some programming in *Ableton Live*, this sound could then be 'morphed' into other sounds by using the MIDI Trainer to crossfade between different parameters.

Morph Triggering System VIDEO
https://youtu.be/PnCYcFUek3o

2.6.4 Ableton Live

In summary, my workflow throughout this project has been to work with *CAMS* and its MIDI Trainer to make mappings of movement to sound in *Ableton Live*. Although *CAMS* can communicate with various programs such as *Max/MSP* and *Pure Data* that may allow more nuanced mapping of movement to sound, my background in electronic production led me to using *Ableton Live* as the primary music program for converting the MIDI from *CAMS* into sound. Although I have created some mappings in other programs for the AirSticks, these will not be included in this thesis.

Using *Ableton Live* was not always ideal, and I would often encounter problems when using *CAMS* with it. Most of the time I would be able to get around these problems through tutorials and various *Max for Live* plugins – a set of open source plugins designed in *Max/MSP* that work in *Ableton Live*. But some problems still remain to date, and the desire for the mapping process to become much faster and more intuitive is often frustratingly strong.

'Building these kinds of instruments requires an enormous amount of experimentation and play. There are simply way too many combinations of features and parameters to manually think about trying – too many decisions to make – and too many combinations that are useless. It's a process that invariably takes way too much time; the ratio of time spent to satisfactory musical experiences is super high.' (Fiebrink et al. 2010, p.4)

Even though I have used the AirSticks in this current form in over a hundred live performances, I consider the use of off-the-shelf hardware, *CAMS*, and its relationship with *Ableton Live* to still be in prototype form. Part of the contribution of this thesis will be the outlining of future hardware and software ideas that have emerged from my practice on this prototype, particularly those that would help to speed up the mapping process. These will be outlined in Chapter 6: Future Work.

2.6.5 Black Box

For now, leaving the flaws of this working prototype to one side, I want to summarise what I had to work with as I embarked on several projects with the AirSticks. At the beginning, I basically had a 'black box' (Fiebrink et al. 2010, p.4), blank canvas, or 'frightening blank space' (Magnusson & Mendieta 2007, p.69). I had a triggering system that could detect velocity and note length, and I could use this information to control the volume, brightness, attack, sustain and release of a triggered sample or synth. I could assign ways of manipulating this triggered sample or synth in six degrees of freedom. I use the metaphor here of a mixing console that provides five sliders and a knob; the x, y and z positions and x and y axes rotations being the five sliders, and the z axis rotation being the knob. All my mappings were made with these simple one-to-one mappings, which I believe bring the most controllability and transparency to an electronic instrument.

To help truly showcase this black box, here is an example of a recent mapping of the AirSticks using just two synths, one for each hand. I have chosen this one for its extremely high prioritisation of transparency, controllability and expression. This mapping does not feature any button presses for changes in mode and is dedicated to showcasing the triggering system, velocity, the control of attack, sustain and release, and the 'morphing' of sounds. I have listed the six degrees of freedom in the table below and shown which parameters they control. Note that both hands are mapped the same way and that in the video, linked to on the next page, the trigger buttons are also used to trigger pulses.

Hand	**Movement**	**MIDI CC Number**	**Parameter**
Left	x position	2/50	Synth 1 OSC B Vol
"	y position	2/51	Synth 1 OSC C Vol
"	z position	2/52	Synth 1 OSC D Vol
"	x rotation	2/55	Synth 1Volume
"	y rotation	2/54	Synth 1 Panning
"	z rotation	2/53	Synth 1 Filter
Right	x position	2/58	Synth 2 OSC B Vol
"	y position	2/59	Synth 2 OSC C Vol
"	z position	2/60	Synth 2 OSC D Vol
"	x rotation	2/63	Synth 2 Volume
"	y rotation	2/62	Synth 2 Panning
"	z rotation	2/61	Synth 2 Filter

Table 1. Movement to MIDI CC to Parameter Mapping.

It is also worth noting here that the 'morphing' system in this mapping through *Ableton Live* is not as intricate or complex as that designed in specific sound morphing research (Rozé et al. 2017; Stasis, Hockman & Stables 2017; Williams, Randall-Page & Miranda 2014; Caetano & Rodet 2010). More sophisticated timbral morphing can be done through audio processing or sound synthesis, either morphing between two sounds or several sounds across an xy 2D field. Mark Havryliv has been building custom software which facilitates timbral morphing through the use of the gestural controller in an xyz 3D space. We are in the late stages of prototyping this software but I will not be commenting much on it other than in Chapter 6: Future Work. Here, I wanted to clarify that the ideas on timbral morphing are only touched upon in this thesis and that the focus will remain on the use of *CAMS* to map the AirSticks through *Ableton Live* for live performances.

Drum Synth VIDEO 'Erasable'
https://youtu.be/vZJN847wvrA

Before I go onto laying out the updated design criteria at the commencement of the formal part of this PhD project, I first want to outline some useful terms in the field of new instrument design.

2.7 New Musical Instrument Design

'Surely one of the earliest applications of tool-making involved making music controlling sound of one sort or another. Whenever this quest started, it still thrives, as researchers and developers rapidly apply new technologies to musical performance.' (Paradiso 1997, p.20)

Before I go onto my methodology section, I want to take a broader look at new musical instrument design through outlining some terminology that has developed in the field. It is not meant to be an in-depth state of the art review of this field. Instead, it is a glossary of terms that I will keep coming back to throughout the thesis. I will be focusing in particular on the field of **Digital Musical Instrument (DMI)** design, where designers, unlike those in the field of acoustic instrument design, use computer processes to make **mappings** between **movement** and **sound**. All musical instruments transform 'bio-mechanical energy to sound energy, using feedback loops based on different sensing channels, such as auditory, visual, haptic and tactile channels. …in contrast with traditional [acoustic] instruments, where energetic modalities are mechanically mediated and where the user gets a natural feeling of the causality of the multimodal interface' (Maes et al. 2010, p.1). DMIs utilise computer processes to make arbitrary connections between movement and sound, as 'energies of the modalities are transformed [firstly] into electronic signals' (Maes et al. 2010, p.1) and then into sound. The question of how to best connect movement and sound in DMIs has been referred to by Maes et al. (2010) as the '**mapping problem**.' Maes et al. attempt to form an empirical solution to this problem through 'experiments that probe the natural tendencies for multimodal mappings' (Maes et al. 2010, p.2) while instrument designers like Onyx Ashanti[46] and Darren Foreman[47] form their design criteria through their own creative practice compromising of informal hypotheses and trial and error techniques.

The sheer amount of options in mapping movement (or gesture) to sound has caused both excitement and paralysis in forming these design criteria.

'The computer can be used to create arbitrary mappings between gesture and sound, thereby providing the possibility of computer-supported sound and directed musical interaction. Thus, the computer allows the creation of new interfaces and sounds never before possible. Unfortunately, with so much freedom to design the mapping between gesture and sound, there has not been a strong set of design criteria developed.' (Fels 2004, p.673)

I chose to explore the potential of instrument design and attack the mapping problem through creative practice. I was interested in developing my own design criteria for new musical instrument design through my own artistic practice and that of other artists I collaborated with.

[46] For more visit http://onyx-ashanti.com/
[47] For more visit http://www.beardyman.co.uk/

Having said that, through my own practice as an electronic and acoustic musician, and as an instrument designer of both digital and acoustic instruments, I have encountered very similar terms to other researchers in the new musical instrument design field, whatever their methodology is in tackling the mapping problem. Though these terms are used mostly in DMI design, a large part of my investigation of instrument design in this thesis will be making comparisons between electronic and acoustic or traditional instrument design, and also a little between instrument design and dance choreography, so it is worth considering the terms outlined below within these fields also. I will elaborate on some of these comparisons in Chapter 5: Discussion.

2.7.1 Concepts in New Musical Instrument Design

Below is a list of some terms in the field of new musical instrument design. I have attempted to find the most simple and concise definitions of these terms made by various scholars. All of these terms are linked to each other in one way or another. It is very difficult to define many of these terms without understanding others and so I have attempted to order these terms in a way that flows logically into the next term.

- Gesture
- Transparency
- Controllability
- Virtuosity
- Intimacy
- Embodiment
- Expression
- Learnability
- Metaphor
- Flexibility
- Reliability
- Design criteria

Gesture most simply refers to the 'incorporation of the body in musical performance…' (Mullin 2010, p.25). These can be grouped into three categories:

- *effective gesture—that necessary to mechanically produce sound;*
- *accompanist gesture—movements associated with effective gesture engaging the whole body but not directly related to the act of sound production; and,*
- *figurative gesture—wholly symbolic gestures of the performer* (Bahn, Hahn & Trueman 2001)

Transparency refers to 'the relationship between what the player does and what sound is produced… [if this relationship] becomes opaque to the audience… the piece [will be] more difficult to appreciate' (Fels 2004, p.674). As discussed above, in DMIs the relationship

between gesture and sound must be mapped and hence the audience has no knowledge of which gestures are actually affecting the sound. In this way, a player can use all three types of gestures to 'sell' the transparency of an instrument.

Controllability refers to how easy it is to gain 'the highest similarity on two performances of the same piece' (Jordà 2004b, p.3) or musical task. This is a very practical term and can be tested through scientific experiments such as the ones outlined in (Hunt, Wanderley & Kirk 2000).

Virtuosity is often referred to as 'extravagant displays of extreme speed or dexterity' (Dobrian & Koppelman 2006, p.3). But in the field of DMI design, where computers can be used to play humanly impossible musical tasks, designers have more often referred to virtuosity as a complete mastery over the control of an instrument 'such that s/he can call upon all of the capabilities of that instrument at will with relative ease' (Dobrian & Koppelman 2006, p.3). This is not to say that the mastered instrument must be difficult to play. 'Rather, virtuosity requires that an instrument's difficulty be related to its technical depth, and that relevant difficulty be related somehow to the production of the resulting sound' (Mullin 2010, p.23).

Learnability refers to how hard an instrument is to master, with DMI designers constantly balancing a 'low entry fee with no ceiling on virtuosity' (Wessel & Wright 2002, p.1). 'Music instruments must strike the right balance between challenge, frustration and boredom: devices that are too simple tend not to provide rich experiences, and devices that are too complex alienate the user before their richness can be extracted from them. [For example] the kazoo is easy to master, but its possibilities are quickly exhausted' (Jordà 2004a, p.60).

Intimacy 'is a measure of the player's perceived match between the behaviour of a device and the control of that device' (Fels 2004, p.672).

Embodiment is attained when a musician achieves high intimacy, control and virtuosity on an instrument. 'When the player embodies the instrument it behaves like an extension of him[/her] so that there is a transparent relationship between control and sound' (Fels 2004, p.672). 'An embodied interface allows expression to flow' (Fels 2004, p.675). Embodiment does have a much more complex definition within the fields of psychology and philosophy, but for the purpose of this thesis it will be used sparingly and relate to the definition above.

Expression is one of the hardest concepts to define, and goes well beyond the scope of this thesis, as it taps into the listener's emotions. According to Poepel (2005) 'performers communicate musical expression to listeners by a process of coding. Listeners receive musical expression by decoding. Performers code expressive intentions using expressive related cues [such as]… tempo, sound level, timing, intonation, articulation, timbre, vibrato, tone attacks, tone decays and pauses' (Poepel 2005, p.228).

As convenient as it may be to have a simple definition of expression such as this, it fails to capture two important concepts of expression. Firstly, performers do not always intend to communicate anything specific to the listener (Gurevich & Treviño 2007). This is particularly true in much contemporary improvised music where the intent of musicians is not to interpret a written score but instead to explore the possibilities of their chosen instrument.

Secondly, this definition does not take into account the performer's movements as much as it does the sonic qualities of the music. A similar emotional communication is made from the performer's gestures even without sound, hence our connection to dance. To make a truly expressive instrument for a live performance context, the link between the expressive gestures and expressive sounds must be strong. This link comes through providing high levels of transparency, virtuosity and intimacy; the player must embody the instrument. 'Designing for intimacy in an intimate musical controller helps create transparency with the musical mapping. This transparency facilitates musical expression' (Fels 2014, p.673). It is the embodiment of an instrument by a performer that allows 'expression to flow through the performer into the instrument and then to the sound and, hence, create music' (Fels 2014, p.672). Furthermore, once virtuosity is gained to a point where control 'is mostly subconscious, the mind has more freedom to concentrate consciously on listening and expression' (Dobrian & Koppelman 2006, p.3).

To elaborate further on the concept of the communication of encoded content, the audience can interpret and feel emotion through a performance in several ways. In a live performance, audience members may tune into the emotion given off by the performers themselves, through whether the performers are smiling or frowning, or through the accompanying and figurative gestures the performers make, or through the connection between the band members and the way they interact with each other.

In a sense, the work described in this thesis is an exploration of the nature of musical expression - through creative practice more than philosophical argument. Keeping an open mind to the definition of expression will be beneficial, though for simplicity's sake, expression is here defined as the element of musical performance beyond the notes.[48]

Metaphor refers to using the audience's common knowledge or 'literature of the physical world to help increase transparency and expression, often through the imitation of playing traditional instruments (Fels, Gadd & Mulder 2002). 'Imitating the gestures of others, in our case the innumerable gestures of musicians playing which we have seen throughout our lives, seems to be a resource for making sense of sounds' (Godøy, Haga & Jensenius 2005, p.11). This literature can extend beyond simply imitating traditional instruments to utilising other real-world physical relationships between gesture and sound (Mitchell, Madgwick & Heap 2012). Furthermore, 'when one hears a sound, one can imagine and empathise with the physical gesture that might have created the sound; in this way, sounds imply gesture, even choreography. Conversely, viewing the physical gesture that a performer makes can influence

[48] From the online Encyclopedia Britannica https://www.britannica.com/topic/musical-expression

the listener/viewer's perception of the sonic expression' (Dobrian & Koppelman 2006, p.2).

Metaphor can also help the performer more easily embody an instrument, allowing the performer to access their existing motor skills on a previously learnt instrument (Mulder 2000). DMIs 'simply cannot reproduce the direct level of interaction found in a traditional [acoustic] instrument, as there can be no actual physical link between the player and the sound' (Mullin 2010, p.3). 'By involving the musician's body and facilitating interactions that are of a more physical nature, an interface can utilize this inherent strength of traditional instruments, and develop musical control that is more natural and powerful' (Mullin 2010, p.5). In addition, with the use of creative mapping approaches, and the fact that DMI designers are not tied to the physical constraints of the relationship between gesture and sound inherent in acoustic instruments, the performer can be freed to express themselves in ways not possible before.

Flexibility refers to the limitless possibilities of DMIs, both sonic and gestural. Flexibility is arguably the greatest strength of DMIs.

Reliability is not a term that is used too often, and when it is used it has two common meanings. Often it can be interchanged with controllability, but throughout this thesis it will be used to refer to whether an instrument works as it should. A reliable instrument does not glitch or stop working or turn itself off during a performance.

The **Design Criteria** is the balancing and prioritising of these often-conflicting aspects of an instrument. Designers must balance the flexibility of the instrument with its intimacy, its learnability with expression, and its transparency with controllability. '…there is a continuum where instruments are on the one side unique and specific and on the other side general and multi-purpose. Creating a digital instrument always involves decisions on where to place the instrument on that continuum' (Magnusson & Mendieta 2007, p.98). Design criteria also tend to change through experimentation and reflection. For a more thorough definition of design criteria, particularly in reference to computer-based musical instruments, refer to Johnston (2009).

Throughout the rest of this thesis I will use the terms outlined in this section to describe my own changing design criteria and to help communicate the ways I approached tackling the mapping problem. Now I will revisit the design criteria for the AirSticks with these terms in mind before laying out my methodology and describing my pivotal projects.

2.7.2 Revisiting the Design Criteria

As listed earlier, the original broad design criteria for the AirSticks was to:

- build on my traditional drum practice incorporating all four limbs;
- trigger and manipulate sounds in a 3D playing space using hand and finger movements;
- access a plethora of mapping possibilities in *Ableton Live* through a MIDI Trainer function in *CAMS;* and,
- create a physically plausible connection between movement and sound which could in turn be communicated to the audience and to other musicians in an ensemble.

The creation of this working prototype and its fortunate timing with the commencement of this research project meant that I could formalise design criteria within the literature on new instrument design, and begin to assess the instrument against these criteria. **Transparency**, **controllability** and **expressivity** were prioritised above learnability and flexibility in an attempt to design a truly new electronic instrument for percussionists – not just an augmented drum kit – that could allow the control of complex sound textures at the same time as facilitating the execution of precise rhythmic gestures in reaction to other performers. We wanted the AirSticks to be used not only to **perform** electronic music, but also as a **tool for improvisation** and **composition** within an **ensemble**. And we wanted it to facilitate more satisfying **collaborations** between electronic musicians and acoustic musicians, visual artists and physical performers without the technology hindering the creative process.

This difficult task was simplified by splitting the AirSticks into several different instruments, or **'template mappings.'** With each new project, specific design criteria were established, and with this came a new template mapping. The more projects I embarked on, the more I could revisit old template mappings to help speed up the creative process. This did reduce the flexibility of the instrument for each specific musical situation, which became a particular burden on my ability to improvise. Through the descriptions of the pivotal projects in Chapter 4: Case Study, the reader will note this changing of the design criteria and the problems faced in using this approach. I will elaborate on this approach and the use of template mappings further in Chapter 5: Discussion, and then outline how we can build on this approach with new hardware and software development in Chapter 6: Future Work.

Again, I want to remind the reader that the AirSticks' focus for the purposes of this thesis is on being a gestural electronic **untuned percussion** instrument within the context of ensemble playing. Some of the pivotal projects I will outline were solo performances and some do feature the playing of melodic ideas, but the discussion that leads on from them will focus on percussive elements and ensemble playing.

2.8 Conclusion

I have now detailed my own artistic background, including a description of the project up to the point of the commencement of this research project. I have also given a brief summary on instrument design, a brief history on percussion, electronic percussion and open-air controllers. I hope that now the reader can begin seeing the endless possibilities of the AirSticks as a tool for electronic percussionists. As stated earlier, these endless possibilities and flexibility of DMIs such as the AirSticks can lead instrument designers to a state of choice and 'creative paralysis', which I indeed often encountered. My remedy for this paralysis was to constantly set out on new collaborative projects on the AirSticks, taking inspiration from the musicians, visual artists and dancers who were just as enthralled by the possibilities of this new instrument as I was. This leads us to Chapter 4: Case Study and the presentation of pivotal projects that I have undertaken with the AirSticks since 2013. But first, I will outline my research questions with this working prototype in mind and the methodology I used in this practice-based research project.

Chapter 3:

Methodology

3.1 Introduction

Having established a working prototype of the AirSticks, I entered this research project to address the **research questions** outlined on page 12. I have included a summary of these questions here for convenience.

Question 1
What are some effective ways to utilise the existing motor skills of expert drummers in designing the AirSticks?

Question 2
What are some effective ways to utilise the latest in motion capture technology?

Question 3
What ways are there to facilitate more satisfying collaborations between artists across different artforms without technology hindering the creative process?

Question 4
What are some effective ways of tackling the mapping problem?

The focus of this research project has been to attempt to answer these questions through my own artistic practice, taking an **artistic practice-based** approach. This approach plays to my strengths as a creative practitioner, and my specialty in imagining ways that the body can be used to improvise, compose and perform electronic music.

I highlight here once more that I am neither a software nor hardware engineer. Throughout the project, I worked in close **collaboration** with computer programmer/software engineer Mark Havryliv, whose specialty was in turning my imaginative ideas into reality and communicating to me what was possible with the technology at hand. Together we formed an **artist/engineer** relationship where our roles were at times very blurry, with Mark himself being an expert multi-instrumentalist and composer. We learned each other's 'languages' and challenged each other's ideas and preconceptions on what was possible. We integrated some methods from **action research** into our **iterative design** process, constantly making revisions to the AirSticks that were informed from my developing creative practice from project to project.

Throughout the project I also focused on being a **reflective practitioner.** I kept a detailed diary of my own reflections and observations of my conversations with Mark, and of the creative work I did in solitude and within other artistic collaborations. After doing some initial interviews with collaborators early in the project, I came to the conclusion that it was more valuable to simply focus on my own reflections and observations. My approach, which had come out of my insatiable appetite for new diverse collaborative projects within my

practice before the emergence of the AirSticks, was to continue to find myself in as many new collaborative musical situations as possible in which to use the AirSticks. I decided, instead of focusing on two or three major projects, to keep pursuing smaller projects with more collaborators. This led to there simply being too many artists to interview them all, and from the transcripts of the few formal interviews I had conducted, I noted that I learnt little more than what was discussed colloquially or through my own reflections and observations. After four years and documentation of over a hundred of these musical situations, I spent the last part of this research project reflecting, writing and constructing a thesis about this ongoing process. This is not to say that I had not made time for reflection, reading and writing during the first part of this research project, but I focused on producing as much output as possible, then blocked out time to write up the thesis and communicate a unified theory of instrument design. This **reflection on action** approach will be discussed further in this chapter, along with the **reflection in action** approach used by reflective practitioners across several artistic and academic fields.

I will now detail my chosen methodology, with particular reference to **practice-based research, action research** and **reflective practice**.

3.2 Practice-based Research

According to Candy (2006), **practice-based research** – often interchangeable with the terms 'practice-led research' and 'practice as research', with subtle differences that I will not go into here – is an original investigation undertaken in order to gain new knowledge partly by means of practice and the outcomes of that practice. In my case the practice was of an artistic nature and hence this research also falls under the category of **artistic research**. 'Sometimes artistic research has much in common with technological, applied research, particularly where the research is aimed at improving materials and techniques or at designing new instruments or applications' (Borgdorff 2012, p.123), and hence, in this case, the research also has elements of **applied research**. Biggs (2000) claims that practice-based research has created much interest in artists and designers because research projects which follow this practice-based approach can include the production of an artefact, in addition to, or even in preference to, a written thesis. It is worth noting that 'this approach is not limited to the creative and performance arts and design disciplines, but is applicable to any discipline where the outcome can be an artefact produced in the workshop or laboratory (e.g., engineering and software design)' (Mäkelä et al. 2011, p.3). This makes practice-based research an even better fit within the AirSticks project as it contains artistic, engineering and software design elements.

Within an artistic practice, artefacts, products or outcomes may come in the form of designs, music, digital media, performances and exhibitions. 'Whilst the significance and context of the claims are described in words, a full understanding can only be obtained with direct reference to those outcomes' (Candy 2006, p.3), and hence I have provided much video documentation of performances in this thesis. Practice-based research not only enriches our world through the creation of these artefacts or products, it broadens 'our understanding of reality and of ourselves – an understanding that is embodied in the products generated by the research' (Borgdorff 2012, p.119). This understanding, or knowledge, is often not reducible to language, hence the necessity of both the artefact AND the text to communicate this knowledge to the wider research community (Eisner 2008). Mäkelä (2009) considers these products or artefacts as 'mute objects which do not reveal their stories until interpreted. The crucial task for each practice-based research project is, therefore, to give a voice to the artefact' (Mäkelä 2009, p.6).

Through giving a voice to these artefacts, and through experiencing the artefacts themselves, knowledge is shared that may be personal, narrative, embodied, artistic or aesthetic in nature (Cole 2008). Artefacts can communicate 'feelings which the artist knows; his[/her] insight into the nature of sentience, his[/her] picture of vital experience, physical, emotive and fantastic' (Langer 1957 cited in Knowles 2008, p.91).

Creative practitioners in this sense possess a knowing 'how' – practical knowledge, embodied knowledge, implicit knowledge, tacit knowledge – as distinct from knowing 'that' – theoretical knowledge, propositional knowledge, explicit knowledge, focal knowledge (Borgdorff (2012). In other words, they possess both theory and practice. It is this relationship between theory and practice, and their interaction with reflection and evaluation that is key in practice-based research. Edmonds & Candy (2010) use this relationship as the basis for their Trajectory Model of Practice and Research. Before I go on to outline this model, and how my project can be assessed through it, I want to firstly outline some important characteristics of action research and reflective practice in relation to this project.

3.3 Action Research

Highlighting once more the cyclical iterative nature of my research project, I will now describe **action research** and the way it was used in my research. 'Action research treats theorists as practitioners and practitioners as theorists' (Kemmis 2009, p.6). Furthermore, it goes 'beyond the notion that theory can inform practice, to a recognition that theory can and should be generated through practice' (Brydon-Miller et al. 2003, p.15). Coming into this research project from a creative practitioner background, action research allowed me to form theories from my creative and professional practice, and put them back into my practice. Its cyclical, or spiraled, iterative nature, outlined in the diagram below (see Figure 17), allows for time to plan, act/observe and reflect. This is a process most artists use in their creative practice but perhaps with less depth and rigour than action researchers, particularly in the reflection stage.

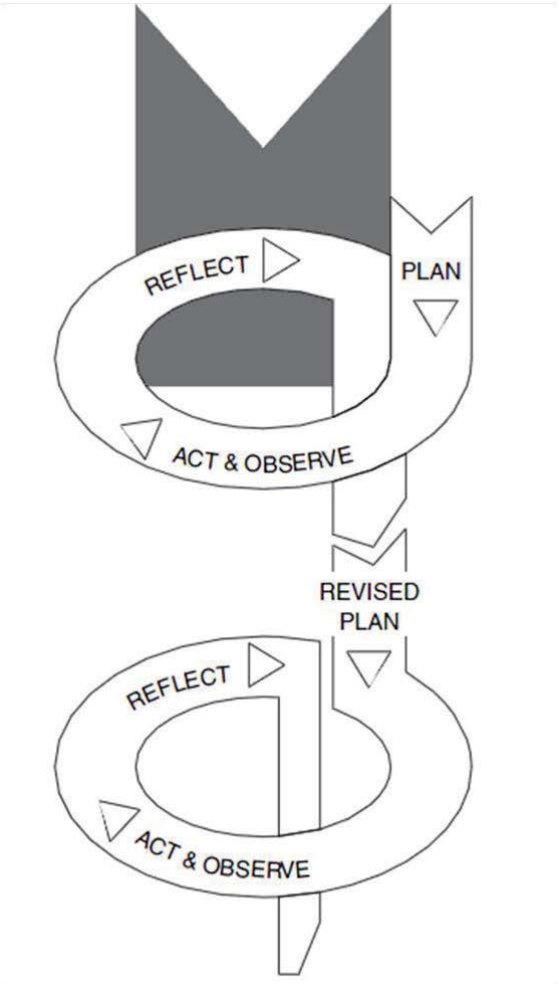


Figure 17. Action Research Spiral (Kemmis & McTaggart 2000)

Planning, in my case, involved preparing for my next performance, making choices on where, when and with whom to play. Often the with whom was answered first, though sometimes a venue and date were in place before the lineup was finalised. As mentioned previously, for each performance a **'template mapping'** was chosen, and often reworked for the specifics of the

performance. I will elaborate on this in Chapter 4: Case Study, but in brief the template mapping would guide me towards different styles of music, and this style of music would often play to the strengths of the collaborators. Since I strived to perform as often and in as many different contexts as possible, my process of planning would be short-lived, though I would find myself back in the revised planning stage very often. I attempted to balance projects that could utilise similar plans, in particular the same mapping and collaborators, with those for which I would need to reinvent the instrument and work with new collaborators.

Acting for me involved some overlap with the planning process in reworking mappings, rehearsing and finally performing. I kept a detailed journal of the process from plan to action, **observing** my collaborators and their comments on the process, but mostly observing how I 'felt' about the process. I asked myself questions like 'is the process satisfying? Is it too challenging? Not challenging enough? Did the mapping allow me to do what planned to do? Much of these observations could be considered **reflections-in-action**, a term I will elaborate on shortly. I also recorded and filmed rehearsals and performances for documentation and for reflecting upon later.

Reflecting for me involved mostly self-reflection through the writing of notes after a performance, and reading of my diary entries, but also the reflection through discussion with software engineer Mark Havryliv and the other collaborators. These reflections would also be logged into my diary and informed the planning of my next performance, which is shown in the diagram above as a **revised plan.** However, I would argue that because I was not working on one creative piece, but in fact on scores of diverse performances with dozens of collaborators, that my 'revised plan' was sometimes much closer to a new plan than presented here. As will be revealed in the next section, the projects I worked on with the AirSticks form a narrative that takes many twists and turns. One project did not always inform the next, and there were times when new mappings were made from scratch to fit my new vision and that of the collaborators for an upcoming performance. It is also worth mentioning that there was a second narrative of interest at play throughout this project: that of the relationship between Mark Havryliv and me. A full examination of this **artist/engineer** relationship is beyond the scope of this thesis; however, I will discuss it briefly in this chapter to uncover some of the methods we used and how they fit in with the action research model.

3.3.1 Collaboration

The form of collaboration with and participation from other creative practitioners discussed above falls in line with some other elements of action research. Reason & Bradbury (2001) elaborate further on action research, describing it as:

'a participatory, democratic process… [which] seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions… to the increased well-being—economic, political, psychological, spiritual—of human persons and communities.' (Reason & Bradbury 2001, p.2)

The involvement of other creative practitioners didn't only provide me with a persistent 'peer review' committee, it forced me to continuously shift my creative goals and hence the workings of the instrument to fit in with the common creative goals of the collaborators. I use the word collaborators here very purposefully, as at the core of my design process was a drive to find myself in truly collaborative creative situations and ensembles – to make the collaborators (or participants, to use a word more commonly used within action research) push the limits of the AirSticks. I went into most collaborative projects with little idea of what we would create; indeed many of the projects I performed on the AirSticks contained much free improvisation, often with musicians I had never met before. Working in this truly collaborative fashion allowed the collaborators to more freely connect with their expertise.

'The principles in a true collaboration represent complementary domains of expertise. As collaborators, they do not only plan, decide, and act jointly, they also think together, combining independent conceptual schemes to create original frameworks.' (Minnis, John-Steiner & Weber 1994 C-2, cited in Elliott 2007, p.30)

I placed great significance on pursuing diverse projects, within and outside of my comfort zone, to create truly original frameworks. I worked with musicians, both seasoned improvisers and composers, on acoustic and electronic instruments, with sound designers, dancers, visual artists, actors and directors. I even had the pleasure of working with a deaf choreographer on a show for deaf and hearing audiences. I chose a handful of these projects to discuss in detail later in this thesis though much knowledge was gained from the projects I omitted (including this show for deaf and hearing audiences).

The pursuit of original frameworks and new knowledge is at the forefront of every research project. Borgdorff defines research as 'a process of investigation leading to new insights, effectively shared' (Borgdorff 2012, p.41). My pursuit for numerous collaborative projects also came from the desire to share the workings of the instrument in intimate settings with expert artists, and find paths for further public performances around the world. After all, it can be thought that 'knowledge creation is a social affair' (Eisner 2008, p.10). Action researcher Marja-Liisa Swantz speaks of her pursuit of social knowledge and understanding in Reason & Bradbury (2001).

'*I do not separate my scientific inquiry from my life. For me it is really a quest for life, to understand life and to create what I call living knowledge—knowledge which is valid for the people with whom I work and for myself.*' (Reason & Bradbury 2001, p.1)

Artistic output in the form of workshops and rehearsals can help share this knowledge within the artist community, but it is the public performances that help 'contribute to the broad agenda of art-informed research, that of enhancing understanding of the human condition through alternative (to conventional) processes and representational forms of inquiry, and reaching

multiple audiences by making scholarship more accessible' (Cole 2008, p.65). Sharing videos of performances online adds yet another form of increasing accessibility to this form of knowledge. At first my documentation of performances, as will be seen in Chapter 4: Case Study, was rough and unprofessional. I soon realised that these documents would not only act as videos which I could return to and reflect upon, and provide in conjunction with this thesis, but also as another form of knowledge sharing to an even broader community. I was constantly surprised in my review of other contemporary instrument designers to find the lack of shared video documentation in conjunction with academic papers. I now rely heavily on professionally recorded footage to spread the ideas of my artistic practice and research as can be seen from the videos linked within this written thesis. This of course was more difficult for older publications, but it now seems disadvantageous to not utilise these modern evolving platforms and tools.

3.3.2 Artist/Engineer Relationship

Throughout my research there was one collaboration that kept evolving more than any other – that was the artist/engineer relationship I had developed with software engineer Mark Havryliv. This relationship formed an overarching narrative of this research that began long before the research was formalised, as described in the section on the project's history. For well over ten years now, Mark and I have been discussing the possibilities of open-air controllers in a variety of scenarios, mostly evolving around my own creative practice. Like many artists doing research, we attempted to solve certain performance 'problems' by assessing which 'solutions' gave the most satisfying experiences (Johnson 2010). 'Much academic research only samples *experiential ("felt") knowing* in precisely defined and narrow terms' (Liamputtong & Rumbold 2008, p.2), keeping the true interpretation of the aesthetic experience of the creative practitioner away from the engineers and scientists who may benefit greatly from these insights (Yair et al. 1999). With Mark and I working in such close quarters, a fruitful artist/engineer relationship flourished where Mark could listen intently to my requirements as an individual, and he could make me aware of any design issues that were apparent. Though 'art may focus more intently on the qualitative unity of the experience (the work) while science focuses more on causal relations and connections… both give us important ways to go on, to go forward, in life' (Johnson 2010, p.150). Moreover, both can benefit each other, particularly the fields of artistic research and engineering and technology, as both can readily utilise action research strategies (Borgdorff 2012). Both also stir 'deep conversation and insightful dialogue' as opposed to 'error-free conclusions' (Eisner 2008, p.7). As a software engineer, Mark took our discussions on how to proceed and upgraded his software in-between sessions. I would then provide quick feedback and continue creating a more stable system. Through this process we didn't only create several iterations of the *Custom AirSticks MIDI Software* and hundreds of mappings within *Ableton Live*, but also a close friendship and a feeling of trust that created a drive for the project and an understanding of the way we worked. This helped us to overcome any uncertainty and ambiguity that often emerges within the design process (Swann 2002). The relationship was also a great vessel for reflection on the project.

3.4 The Reflective Practitioner

The term **'reflective practitioner'** was coined by Donald Schön (1983) in his seminal book of the same name. Originally intended to describe a new form of practice within diverse professional fields that could adapt to constantly changing environments through action and reflection, many artists have recently taken up elements of this practice within their own diverse practice. Artists must constantly re-contextualise and re-position their work in an ever-changing art market, and hold themselves accountable to grant providers and to the public. This leaves little time for reflective practice which is paradoxically what is most needed to maintain a high quality artistic output. Borgdorff (2012) writes passionately about the need for reflective practice in the arts, and for the role of formalised research to provide this space.

'Both the pressure of the art market and the strains of art production leave artists little room to 'stop and contemplate' what they are doing. Many artists must operate as free enterprisers in the market of the 'creative industry', a market that is not oriented to reflection, but which expects its suppliers to deliver a constant stream of new products and projects' (Borgdorff 2012, p.118).

He also argues that 'this reflexiveness of art, in conjunction with the reflexive stance of the artist, is one of the most important rationales for research in the arts' (Borgdorff 2012, p.117).

Given this wonderful opportunity to enter this practice-based research project that gave me the time and space to 'stop and contemplate', this thesis is primarily a documentation of my reflection on an artistic journey of incorporating new technology into my own creative practice utilising my professional experience as a drummer, particularly in the form of improvisation and composition through improvisation. This new technology was incorporated into my practice as I desired to improvise electronic music the way I had always improvised acoustic music, combining my training as a drummer within the improvised music tradition, with my aesthetic and love for electronic music. Here I draw similarities with other creative practitioners such as Simon Barker (2015) and his writing on rhythmic improvising in the jazz and Korean drumming traditions, Sandy Evans (2016) and her writing on rhythmic and melodic improvising in the jazz and Carnatic music traditions, and Ben Carey (2016) and his writing on improvising on the saxophone with the accompaniment of generative computer processes. Several expert musicians who specialise in improvising are now formalising their research on combining improvisational techniques of different music cultures, be it acoustic, electro-acoustic or electronic. These musicians are making their art, reflecting on it and within it, making more art, more reflections and so on. At some point in their process they evaluate their practice and reflections, and formalise them into written papers. This is not to say that musicians who are not undertaking PhDs or other academic pursuits are not reflecting on their practice, in fact being a musician and a researcher does have a lot in common, as Schön (1983) points out.

'When good jazz musicians improvise together, they also manifest a "feel for" their material and they make on-the-spot adjustments to the sounds they hear. Listening to one another and to themselves, they feel where the music is going and adjust their playing accordingly… As the musicians feel direction of the music that is developing out of their interwoven contributions, they make new sense of it and adjust their performance to the new sense they have made. They are reflecting-in-action on the music they are collectively making and on their individual contributions to it, thinking what they are doing and, in the process, evolving their way of doing it. Of course, we need not suppose that they reflect-in-action in the medium of words. More likely, they reflect through a "feel of the music…"

... In such processes, reflection tends to focus interactively on the outcomes of action, the action itself, and the intuitive knowing implicit in the action' (Schön 1983, p55-6).

This sort of reflection-in-action is differentiated by Schön from reflection-on-action: that is reflection that occurs after the action has occurred, usually after some time has passed to process what has occurred. Reflection-in-action 'takes place "in the moment," to use the phrase from theatrical improvisation theory, in a way that decreases its chronological–physical separation from action, such that reflection can usefully be said to take place in the midst of action… reflection-in-action and reflection-on-action form the two ends of a continuum of reflective practice' (Yanow & Tsoukas 2009, p.2). I argue that within this continuum there are slight variations in reflection-in-action that are worth pointing out in reference to improvisation and instrument design.

When an improvising musician is in a state of flow they are in fact reflecting-in-action in a very different way to one who isn't. And it is this state of flow that many improvisers strive to attain, not over-thinking but simply being and playing, through a "feel of the music."

This type of flow is much harder to attain while developing a new instrument. A very different sort of reflecting-in-action occurs when one is trying to learn to improvise on a new instrument, particularly when that instrument is one which the performer has the ability to change at will for the next performance. I would take mental notes of things I wanted to change on the instrument during an improvisation, but of course I did not want to stop the performance to write down these ideas, nor would I want these mental notes to remove me from my focusing on the performance itself. This would very rarely occur to me on an acoustic kit since the instrument is more 'conceptually complete. …[DMIs like the AirSticks undergo] a constant series of revisions, redesigns and upgrades' (Ostertag 2002, p.13). 'The digital musical instrument is perpetually evolving, although a few designer/performers have made efforts to "freeze" the state of the instrument to gain better mastery of it' (Magnusson 2010, p.65). Unlike traditional instruments like the drums, piano or even the *Theremin*, DMIs cannot be explored within their physical and sonic constraints. The improviser, who is often also the designer or at least has the capability to change the instrument significantly, constantly questions whether s/he should redesign the instrument in a way that would allow an easier access to her/his musical ideas. In my experience, this practice doesn't result in the most satisfying of improvisations as

questioning the capabilities of the instrument can easily take me out of the state of flow. I believe it is important to make a clear distinction between improvising and reflecting, making sure to reflect properly after a state of flow has been fully exhausted. Improvising while reflecting can also lead to great insights, but must be balanced against truly committing to the constraints of a particular 'frozen' mapping (Tez & Bryan-Kinns 2017).

As discussed above, the way I continually redirected the development of this instrument was to find myself in as many diverse musical situations as possible. This meant that I would need to prepare and revise the instrument for each new public performance in solitude. These hard deadlines were invaluable for my practice and research. I took note of my most satisfying improvisations, which would usually occur once I settled on a mapping and got comfortable with it, and took time to reflect *on* these, trying to recall any memories of my reflections *in* or during the improvisations. In this way, the 'self is inescapable, because the person creating, responding to, working on, developing or evaluating performances, artefacts and practices is central to those activities' (Griffiths 2010, p.185). Artistic research in its very nature is:

'about the self-reflective and self-critical processes of a person taking part in the production of meaning within contemporary art, and in such a fashion that it communicates where it is coming from, where it stands at this precise moment, and where it wants to go.' (Hannula, Suoranta, & Vadén 2005, p. 10)

Adding elements of action research in a self-reflective artistic practice-based research project such as this one is also evident. One of the main aims of action research is:

'not to bring practitioners' practices into conformity with (external) theorists' theories, but to have practitioners be theorists and researchers – to give practitioners intellectual and moral control over their practice. Their action research, as a practice-changing practice, is a self-reflective process by which they remake their practice for themselves.' (Kemmis 2009, p.7)

This control over their practice is invaluable in making sure that the artist's creative practice, especially those who pursue artistic research in a more formal context, is not weighed down in theory. Part of my self-reflection as an artist was checking in to make sure I was staying true to my values as an artist. There were many elements of my research that indeed helped me stay true to my values, especially the process of allowing time for reflection. Over the course of this research project, my artistic practice continued to change and evolve not only through self-reflection but through feedback from friends, family, a growing fan base, random passers-by and reviewers. However, the most valuable feedback for developing the instrument has come from collaborators: musicians, visual artists, directors, actors and dancers who have pushed the instrument into new fronts and moulded their own creative practice accordingly to work with the AirSticks. These collaborators, especially ones whom I have ongoing projects with, have reflected-on-action with me. From this set of creative projects, which culminated in public

performances and online videos witnessed by an audience of hundreds of thousands, I have selected a handful of pivotal projects, or case studies, which I will present in the following chapter. But to finish off this chapter, I will now return to Edmonds & Candy's Trajectory Model for Practice and Research.

3.5 Trajectory Model for Practice & Research

Edmonds & Candy (2010) 'describe a model of practice-based research that represents the relationship between **theory, practice** and **evaluation** in cases where the practitioner follows a specific trajectory or route influenced by individual goals and intentions' (Edmonds & Candy 2010, p.470). This **Trajectory Model for Practice and Research** explores the order in which the practitioner puts these three elements together.

Practice here is defined as anything that constitutes a creative output; in the AirSticks project's case the creative output comes in the form of live performances, recordings, films and custom software or hardware that facilitate this creative output. 'Experiencing these works is usually necessary for a full understanding of the practitioner's contribution to new knowledge' (Edmonds & Candy 2010, p.471). My practice involved repetitive exercises, mapping new relationships between movement and sound, rehearsals with other artists, workshops, brainstorming and conceptualising. Most creative output was itself part of my practice too, feeding into further creative output, creating a loop where creative output informed practice, which in turn informed more creative output. One of the things that the Trajectory Model for Practice and Research explores and attempts to define is the way that the creative output informs practice.

Theory within practice-based research often comes in the form of an individual's unverified opinion or informal hypothesis about what constitutes a good creative output. An informal hypothesis before evaluation can be thought of as design criteria that must be 'developed into more rigorous forms through the exploration of theoretical knowledge and the examples of other practitioners' (Edmonds & Candy 2010, p.472). Part of the theory used to form my design criteria for making the AirSticks is based on literature from other instrument designers and musicians, while the rest comes from theory developed through my own practice. In this way, practice informs theory, though a high level of theory on electronic music production, instrument design and electronic percussion was needed to inform the practice. Of course, since the practitioner is often a professional in the field of their own research, their history of practice leading up to the project brings a bountiful amount of theory in their specific field. Practitioners are constantly negotiating between practice informing theory and theory informing practice.

Evaluation of a theory also informs practice. Evaluation in my case developed through reflecting on my documentation. Documentation came in the form of a journal where I logged observations of my own practice, the way it was influenced by musicians that I collaborated with, and discussions with my main collaborator, computer programmer Mark Havryliv. My relationship with these other professions and artistic practitioners of diverse skill sets, particularly Mark Havryliv, was not only a source for reflection and evaluation, but an invaluable source for learning and developing ideas. Further documentation also came in the form of a small number of formal interviews with those involved in the project, but more so my own observations of these collaborators and informal discussions with them. I also gathered

some evaluation from reviews of the creative output from outside sources such as formal performance reviews both in print and online, and from informal discussions with people who had seen me perform, both people I knew and those I had never met.

The evaluation of all this documentation helped to modify the design criteria and framework, creating a new theory on which to build the practice. This cycle continued until the final evaluation was turned into a public document in the form of this thesis.

The trajectory of practice and research in this project is very similar to that of Johnston (2009), drawn up after he had completed his practiced-based research project (see Figure 18). Like Johnston's trajectory model, my project began with practice. Edmonds & Candy (2010) note that in Johnston's case 'theory about sound synthesis and physical modeling was important to the practitioner's design of the works' (Edmonds & Candy 2010, p.471). Similarly, theory about percussion, electronic production and instrument design was important to my practice. This practice in fact began long before embarking on any formal research. The output from the project is highlighted in this figure as works, criteria, framework and results, symbolised by W, C, F and R respectively.

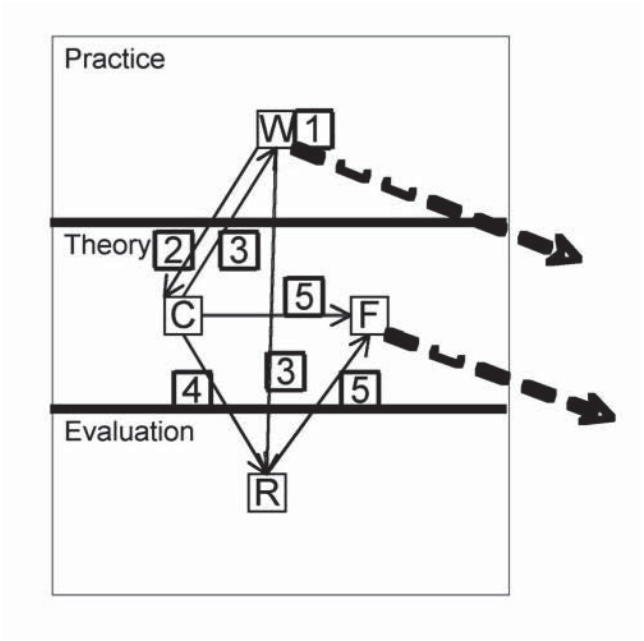


Figure 18. Trajectory Model for Practice and Research for Andrew Johnston (Edmonds & Candy 2010, p.471).

In my case, my trajectory began with my works (or practice) informing my criteria (or theory). Upon reflecting on my practice as a drummer and electronic producer, I set out to create informal design criteria for a new instrument. Upon researching the theory on instrument design, my design criteria were formalised and put into practice as further works were created, in the form of performances on the new instrument. Practice and theory constantly informed each other throughout this project creating an iterative cycle through **action research** discussed earlier. My practice and theory will continue to inform one another well beyond this research

project. The reflections upon the performances and the design criteria are described here as results, which after being evaluated, combined with the evaluation of the design criteria to form a framework or unified theory on new instrument design. This framework is communicated through this written thesis and the documentation provided throughout the thesis. This written document can be considered as a snapshot of my current evaluation of my theory and practice, just as the live performances can be considered as snapshots of my practice.

In summary, at the end of this particular trajectory of practice and research, my output and contribution to knowledge in the field of instrument design comes in the form of:

- documenting and evaluating the process of designing a new instrument;
- theoretical understanding of instrument design and music production tools for the collaborative performance, improvisation and composition;
- a new musical instrument; and,
- creative outputs such as live performances, video and recorded music.

To further highlight the structure of my practice-based research project, and to compare it to other practice-based research, I have included here an overview of the entire structure of the project through a figure taken from Johnston (2009) (see Figure 19). The translation of these processes and outcomes for my project are as follows.

- **Literature** – literature on the state of the art of instrument design, particularly electronic percussion and gesture controllers;
- **Develop initial criteria** – developed formal design criteria from this literature;
- **Prototype development** – made several 'prototype' mappings of the AirSticks for solo playing;
- **Compositions** – performed, filmed and recorded several solo improvisations and compositions on these prototype mappings;
- **Applied criteria** – continued to develop the design criteria for new mappings, new software and hardware for the AirSticks;
- **Software/hardware** – made further adjustments to the mappings and to the software;
- **User study** – collaborated on projects with other artists to further 'test' the latest mappings made;
- **Framework/refined criteria** – the final refined criteria for building this new instrument is written up in this thesis;
- **Theory of musician** – a new contribution of knowledge to the field of instrument design is outlined throughout this thesis.

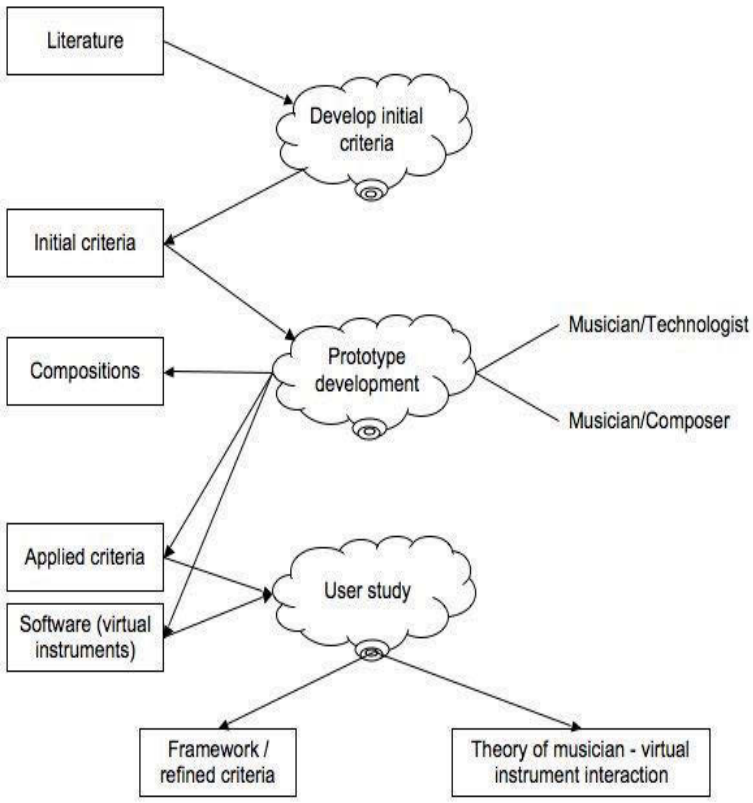


Figure 19. Overview of the research project. Processes are shown as clouds, concrete outcomes as boxes (Johnson 2009, p.45)

Having outlined my methodology for this self-reflective artistic practice-based action research, I will now present some of my pivotal projects.

Chapter 4:

Case Studies

4.1 Introduction

As mentioned earlier, the AirSticks have been used in over a hundred documented musical situations since the beginning of this PhD. These include live performances, recordings, films, talks, rehearsals and workshops.[49] Some of these musical situations can be grouped into projects that include a variety of these situations. In this section I will describe in detail a handful of pivotal projects that reshaped and redefined the AirSticks. These descriptions will take the form of short narratives, often associated with the creative output of a documented performance. Each narrative will reveal challenges that we as collaborators met and the discoveries we made. We constantly had to make compositional and aesthetic decisions based on our own tastes and preferences and the limitations of our technology. I will expand on these discoveries in the following chapters, drawing out the concepts raised in the descriptions of these pivotal projects.

But before I go into describing these pivotal projects in detail, I want to give the reader an overview of the longer narrative that these projects formed together by listing them in order and writing a line or two on each of them. I will then also discuss what I call the 'one-person band dilemma' in instrument design.

[49] For a full listing of these see **Appendix C**

4.2 Pivotal Projects Overview

Air Vacuum (3/2013 -)

A solo performance where I took inspiration from the room itself, controlling the feedback of a microphone in a room to generate tones.

Vacuum Duos (8/2013 -)

Having established a way of sampling, triggering and manipulating my sonic environment, I next took inspiration from the live sampling, triggering and manipulating of other musicians in a series of improvisations and compositions.

Dark As A Dungeon (11/2013)

On a slight detour, but using some of what I had learnt from the *Vacuum* pieces, this was a live musical accompaniment to a silent film. Though much of the piece involved the manipulation of the second musician on guitar, here I also took both visual and sonic inspiration from the film in what could be considered as a sound design role.

H2.0 (11/2013)

On a major detour, and instead of seeking inspiration from a sonic palette, I set out to be inspired by the gestures of a conductor in a collaborative piece with a visual artist who had built an interactive projection mapped to a virtual choir. We also outlined a narrative for this performance which led us to using a sonic palette consisting mostly of water samples.

Malarkey (3/2014 -)

A project that combined a previous vocal *Vacuum* project with the "*H2.0"* project, though for this project we scrapped the conductor gestures and focused on writing songs and using the interactive visuals as a backdrop.

Nine Lives Live (8/2014 -)

My first proper investigation into using sound synthesis with the AirSticks. It was also the first time I used the updated version of *CAMS* which allowed me to morph between sounds.

Duo with trumpeter Ellen Kirkwood (10/2014)

Combining the use of sound synthesis with a *Vacuum* project.

The Sticks Dock Residency (11/2014 – 1/2015)

Expanding further on the mapping used with Ellen Kirkwood, I added a palette of more traditional one-shot electronic percussion samples for this beat-oriented improvisational project.

The Sticks Debut Album (2/2015)

This project was my first major recording project, developing, rehearsing and arranging original compositions from improvisations with the core trio from the Dock residency.

The Sticks "Visualised" (4/2015 -)

A collaboration with two artists to visualise a live performance of *the Sticks* original music.

AirStorm (4/2015 -)

Another collaboration with one of the visual artists from *the Sticks "Visualised"* in visualising the AirSticks, this time in a solo context.

The Sticks Covers Series (7/2015 – 1/2016)

This was a series of covers performed live to camera by *the Sticks* trio with a couple of guest vocalists, often using the sonic palettes from the original songs.

Tuka's Like A Version (11/2015)

A two-song collaboration with Australian MC for live radio and YouTube. In one piece my role was to pull apart samples from a fully produced electronic backing track and reinterpret it for a live performance on the AirSticks. In the other piece, I returned to the use of the synthesised sounds in reinterpreting one of *Tuka's* original songs with a live band.

Creative Tech Week Talk (4/2016)

A talk about the diverse uses of the AirSticks while demonstrating the instrument.

CF1 (6/2016)

A reinterpretation on the AirSticks of an original electronic music piece with the help of a choreographer.

Da Funk (7/2016)

An experiment in remixing and performing a simple electronic instrumental pop tune.

4.3 The One-Person Band Dilemma

'As a performer, my goal when constructing the instruments I will play is clear. I need instruments that are enjoyable to play and that mutually enhance the experience when playing with other musicians. Thereby allowing me to create or co-create music that will surprise me as much as possible, that will keep revealing little hidden secrets at every new listening, that I will therefore enjoy listening on play back. Music not necessarily better, nor worse, than a piece that I could compose in the studio; but music, in essence, that could not have been created in any other possible way.' (Jordà 2005, p.4)

Before I go into these pivotal projects in more detail, I want to outline what I call the 'one-person band dilemma' in the design of a new instrument. At the start of the process of designing a new instrument, work needs to be done in **solitude** to get the instrument to a standard that would allow it to be played within an **ensemble**. Much practice needs to go into getting comfortable on and familiar with a particular mapping. The mapping process itself is at first so slow that changing mappings in front of other performers can really kill the creative flow of a rehearsal. This is why my earliest performances on the AirSticks were solo performances. It was never my intention to make a solo or **loop**-based instrument that would allow me to perform as a one-person band, but it was something that had to be done to develop the instrument further.

Having played in hundreds of group situations on the drum kit, and rarely playing drum solo performances, I had the desire to use the instrument in the development of **compositional** ideas and in **improvised** ensemble contexts. Electro-acoustic improvised music pioneer Evan Parker[50], in an interview with fellow improviser Derek Bailey[51], states that for him the 'ideal music is played by groups of musicians who choose one another's company and who improvise freely in relation to the precise emotional, acoustic, psychological and other less tangible atmospheric conditions in effect at the time the music is played' (Bailey 1993, p.81). I felt that to be in tune with all of these conditions I needed to work on a solo mapping that could later be expanded to an ensemble context. Unfortunately, in my research, I found very few instruments that were being designed for ensemble playing. Most new instruments we see today including the *MPC*, Imogen Heap's *Mi.Mu Gloves* and Onyx Ashanti's *beatjazz* are designed for solo playing. I find that many instrument designers fall into a trap of using the latest technology to replace other musicians, for financial or aesthetic reasons, particularly through the use of long samples and loops. Using loops instantly makes an instrument less transparent, as physical movements stop relating to the sound being heard. This has been a very difficult concept to grapple with and I will return to it in more detail in Chapter 5: Discussion, but it is worth noting here that I had a very frustrating time mapping for solo performances as I wanted to create a denser sound but could not figure out how to do this without looping.

What added to this frustration early on was that I often found myself completely paralysed by the endless possibilities I had for controlling *Ableton Live*. I had to keep asking

[50] For more visit http://evanparker.com/
[51] For more visit https://www.theguardian.com/news/2005/dec/29/guardianobituaries.artsobituaries

myself two major questions:

- What sonic palette should I use in this performance?
- How do I want to move in this performance?

I would continuously oscillate between these two questions throughout the entire AirSticks project and also within each project. Sometimes I would find inspiration to use a certain sonic palette, other times I would find inspiration from wanting to move certain ways.

Before I had even made a sound on the AirSticks though, the drumming **metaphor** had been established through the *Custom AirSticks MIDI Software's* triggering system. All I knew was that a strike would trigger a MIDI note on, and that the *CAMS* MIDI Trainer function would enable me to map a different parameter to a change in position or orientation on each axis. With this question of 'what movement to use' answered to an extent, and with this type of movement playing to my strength as a drummer, I shifted my focus to the other question: 'where to find the inspiration for the sonic palette of the AirSticks?' In later projects, I took inspiration from the acoustic instruments, sound synthesis, the elements (water, air, fire, earth), one-shot sample banks and cutting up recordings that I liked. In my first solo performance, however, I began with one inspiration, the room itself.

4.4 Pivotal Projects

4.4.1 Air Vacuum (3/2013 -)

"Air Vacuum" is a semi-improvised piece for solo AirSticks. It was performed on a variety of occasions from May to June in 2013. I have here linked the reader to a performance of this piece at the Creativity and Cognition Conference at the University of Technology, Sydney in June 2013. Please excuse the audio and video quality (the video is pretty much unusable). As you will see the quality of these performances and the documentation improves throughout this PhD.

"Air Vacuum" by Alon Ilsar (19/6/13)
https://youtu.be/OvT02BuBvDM

I have chosen this project to start off this series of narratives because it is a rare solo project, and as mentioned previously, work needed to be done in solitude to get the AirSticks up to speed to work in ensemble contexts.

In "*Air Vacuum*" I took inspiration from my fascination with room feedback. I decided to solve my problem of what sonic palette to use by sampling the room. Since the AirSticks were played in the air, it seemed conceptually fitting to sample and control the feedback of the room I was in through **effects** such as reverb, delays and distortion. I had previously used *Ableton Live* in a similar way to make drones that ended up as beds for another electronic project. I created feedback tones by running a live microphone through an effects channel and turning up the gain enough so that the signal started to go through the microphone again, creating the feedback loop. This is far from a new idea in electronic music with composers such

as Alvin Lucier[52] and Steve Reich[53] famously exploring this concept, but it seemed fitting to try this with AirSticks because of the relationship of the sound to the body movement. As a performer, I had to react to the feedback of the room. If I stayed in a certain position for too long the feedback would get overpowering. If I didn't stay in a position for long enough then no sound would be created. Different rooms would react differently, as would different microphones and PA systems. The room became my instrument and the feedback my visible dance partner. Still I wanted to have complete control over the instrument and not for it to lead me.

Using feedback created a greater dialogue between me and the instrument. It also allowed me, in the solo context that it was used, to have something to bounce off, to be inspired by the way the room resonated and to find the aesthetically pleasing tones of the room. Lastly, it allowed me to manipulate other sounds in my environment, whether it be the clicking of the plastic *Razer Hydra* controllers or the audience shuffling in their seats.

I made many attempts to map different movements to control the microphone level, effect send, panning and filters. The xy position and z-rotation of my right hand became a comfortable and meaningful way to filter sounds, creating the feeling that I was 'tuning' the room by picking out different frequencies on the x-axis, with higher frequencies on my right. I could turn different frequencies up by lifting my right hand higher and fine-tune the frequency by rotating the wrist on the z-axis, like turning an imaginary knob. The metaphor of an EQ graphic curve and an imaginary mixing console with giant sliders and knobs seemed appropriate to use for this 'tuning' of the room. It also meant that the intensity of the feedback would build as I lifted and twisted and I would then need to react by lowering the hand and retracting it into my body.

I could turn this feedback up more by pressing on the trigger button, a **discreet** movement the audience could not see. This sensation of in essence **squeezing** the sound out of the controllers seemed extremely fitting and made me want to investigate the possibilities of new hardware for the AirSticks, a topic I will touch on later in the thesis in Chapter 6: Future Work. The left hand was used more subtly to control various delays, again turned up with the trigger button, and up further with the rising of the hand.

On the next page is a summary of the mapping used for "*Air Vacuum.*"

[52] For an example Alver Lucier's work visit https://youtu.be/fAxHlLK3Oyk
[53] For an example Steve Reich's work visit https://youtu.be/fU6qDeJPT-w

Hand	Movement	Mapping
Left	x position	Distortion Wet/Dry
“	y position	Reverb Wet/Dry
“	z position	Bit Deduction Wet/Dry
“	x rotation	Volume
“	y rotation	Panning
“	z rotation	Filter
“	Joystick Up/Down	Reverb Time
“	Joystick Left/Right	Reverb Spin
“	Trigger Button	Send to Effect
Right	x position	Delay Frequency
“	y position	Delay Wet/Dry
“	z position	Delay Time
“	x rotation	Volume
“	y rotation	Panning
“	z rotation	Filter
“	Joystick Up/Down	Delay Feedback
“	Joystick Left/Right	Delay Spray
“	Trigger Button	Send to effect

Table 2. Movement to Parameter Mapping for “*Air Vacuum*”

It is worth mentioning that there are also discrete MIDI messages sent in the form of MIDI notes from buttons on the controllers and from the *SoftStep*. These are used to turn effects on/off, record sounds into the *Looper* (a looping plugin in *Ableton Live*), mute different sounds and trigger sounds with the feet.

This mapping was not my original idea; I had always imagined that sound would only be created through a striking movement like in any percussive instrument. My first attempt involved fading up the microphone on the rotation of the wrist around the x-axis, like the triggering system, but this movement seemed unnatural and I reserved it for triggering shorter sounds.

The lifting of the arm up higher to attain more reverb, opening up the body like breathing in the sound, quickly became a staple of most of my mappings. Without my knowledge, Heap was using a similar metaphor with the early *Mi.Mu Gloves*; the higher her arms were, the greater the reverb (Mitchell & Heap 2011; Mitchell, Madgwick & Heap 2012). Panning sound with the rotation around the y-axis also became a staple in most mappings. The gesture of pointing in one direction and the sound coming from that speaker seemed incredibly logical and meaningful, and again, in investigating other new instruments like the *Mi.Mu Gloves,* I discovered this similarity with other designers’ mappings too. This inspired the desire to be able to move sounds around a room with more speakers which I investigated more recently.

I also had the desire to be able to record small snippets of the feedback and assign them to the virtual boxes around me, as part of *Box* mapping I was using at the time, to allow playing the instrument more percussively. But I found this very difficult to map through *Ableton Live*. I could not predict the start and end points of the samples I would make on the fly and hence could not consistently record desirable samples for percussive playing. This desire is still being investigated now and is a problem that has occurred throughout several projects. It has partly been solved through the use of **granular synthesis**.

I finally decided to cave in to the idea of creating long loops of my playing. It became a compositional decision to record a long, improvised phrase of feedback tones and then play off the loop with further improvising. I justified using this looping system because I could also manipulate it when it was being played back. The loop would also feedback through the microphone and became another sound to play off, something I yearned for in the solo context. I also realised, with the small snippet recording not working as desired, that I should add a layer of percussive sounds to play over the room feedback towards the end of the piece, to showcase the triggering system of the AirSticks. I was inspired by a bank of samples given to me by a collaborator and chose a set of samples created by electronic producer Richard Devine[54].

Once I had a rough idea of the mapping I would use in an *"Air Vacuum"* performance, the process of preparing for the solo performance was one of solitude and trial and error. I recorded myself in very high quality within *Ableton Live* and began to record hours of improvisation, constantly tweaking and adding to the mapping. I knew the performances I had booked would need to be between 5 -10 minutes so I began to improvise pieces of that length. I also took inspiration from the raga form used in Indian classical music, beginning by setting up a drone and playing spaciously over it until climaxing with the addition of percussion, and ending with a short reprise of the drone. Quickly the improvisations gained structure as I compared different recordings. Each time I would need to decide whether the mapping needed to be changed or whether I simply needed to get used to the mapping. This iterative process of improvising with a mapping, reworking the mapping, and improvising again and again over more refined mappings and structures became one of my main ways to not only write compositions and prepare for performances but also create new mappings.

"Air Vacuum" was played several times in public concerts. The most well documented of these performances was at the Creativity and Cognition Conference 2013 linked above. A performance with a similar mapping that was better documented is "*Robotross Part 1"* by *Faulkland*. Here a microphone is used to create feedback and manipulate the room and the rest of the band. We were exploring the genre of drone music in this piece which does not lead to a very exciting performance on the AirSticks, but I still think it is worth viewing even just the first few moments of this link to show the development of the instrument.

[54] See http://www.devinesound.net/

"Robotross Part 1" by Faulkland (14/5/13)
https://youtu.be/tUuTJH1pvjU

To recap, the major revelations I took from working on "*Air Vacuum"* was identifying that although I wanted to make an ensemble instrument, I needed to dedicate time to create solo performances through solitude and trial and error. Also, it was a difficult task to create a piece on the AirSticks from scratch without having some idea of what I wanted the piece to sound like, especially this early on in the design process of a new instrument.

4.4.2 Vacuum Duos (8/2013 -)

One of last performances with the *Air Vacuum* mapping involved short overlapping duos with other acoustic instruments on either end of my solo. This led to the idea of **collaborating** with a violinist to make an electro-acoustic improvisation, "*Violin Vacuum One.*"

"Violin Vacuum One" by Bronwyn Cumbo & Alon Ilsar (24/9/13)
https://youtu.be/DVLB6jsyFho

Since this early mapping, the *Vacuum* mapping has been developing in two ways to accommodate different types of collaboration. One use of the mapping was for improvisation or exploration of compositional ideas, while another was for the performance of a composition itself.

"Violin Vacuum One" was the first in the series of duos utilising the *Vacuum* **template mapping** for improvisation. This mapping built slightly on the *Air Vacuum* mapping by adding a granular synthesis function that I will describe shortly. This series included duos with a drummer, vocalist, bassist and guitarist. The *Vacuum* template mapping allowed me to sample and manipulate my sonic environment, in this case the violin played by Bronwyn Cumbo. I wanted to be able to capture the sound of the other musician, literally by making gestures like grabbing and squeezing as discussed in the *Air Vacuum* project.

The *Razer Hydras* do allow this kind of tactile and haptic response to an extent through the pressing of buttons. The trigger button, for example, uses a spring mechanism to push back against the finger. I tried various ways of capturing the sound. My original intention was to record on the upstroke and play on the downstroke. This was sparked by the desire to communicate to the acoustic musician as to when s/he was being recorded. Unfortunately, the effect of the gesture of lifting the hands up into the air was confusing, resulting in the

conventional response of the other musician to wait for the downbeat to play. One performer I collaborated with on this mapping did not feel comfortable simply 'feeding sound into the machine' without me contributing further sounds of my own. For later duos, I did introduce my own palette so that these sounds could inspire the acoustic musician further. This same performer did also comment on liking the 'energy' given off by the gestures, though he felt that the flow of musical ideas was interrupted by the grand gesture used to turn the recording function on.

In general, what I wanted was beyond the capabilities of *Ableton Live*, desiring things like finding the peak of the last sample recorded and reorganising the sample to be triggered from that point all in real-time. I wanted to turn all sounds into percussive sounds like kicks and snares, augmenting pitched samples into percussive ones through filters and the use of white noise generators, so as not to deal with harmony or melody. I began to investigate granular synthesis**,** as can be seen and heard in the video, in a similar way to Michel Waisvisz with his instrument *The Hands* (Krefeld & Waisvisz 1990). A strike through the air would play back the last two seconds of what the other musician had played. The velocity of the strike would control the velocity of the sample. Pitch could be controlled by moving along the x-axis, grain size and spray could be controlled with the thumb and the sample would remain being played forwards or in reverse by rotating down or up respectively on the x-axis, until a lift above the trigger point would turn the sound off. Here is a table to help show this granular synthesis feature. Both hands are mapped in the same way. Note that position is not used in this mapping as the granular synthesis was only triggered in certain boxes.

Hand	**Movement**	**Mapping**
Left/Right	x rotation	Pitch
"	y rotation	Panning
"	z rotation	Filter
"	Joystick Up/Down	Grain
"	Joystick Left/Right	Spray

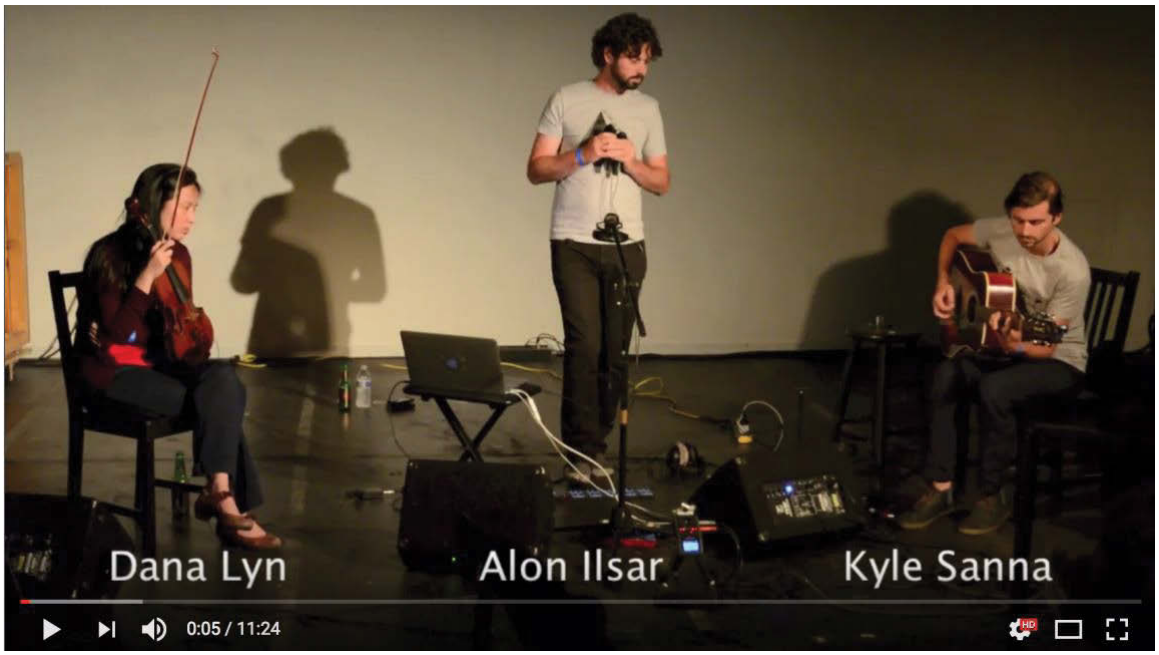
Table 3. Movement to Parameter Mapping of Granular Synthesis.

The use of this type of drumming metaphor can also be explored to communicate ideas and cues to the other musicians. I will elaborate on this further in Chapter 5: Discussion.

On top of these options for sampling and triggering, the *Vacuum* mapping also features a set of gestures that enable the manipulation of the acoustic instrument in real-time. These include reverbs, delays, resonators, distortions, bit reducers, filters and panning, all mapped to gestures that can be seen and learnt by the other musician. Mode changes between these effects, however, are mapped to discreet buttons and hence hidden from the other musicians and the audience.

Since "*Violin Vacuum One"* I have developed the *Vacuum* template mapping a little further, incorporating more use of the *Looper* effect in *Ableton Live* and mapping its volume to

the x-axis rotation to allow the fading in and out of looped fragments with a similar motion to a strike. In 2016 I performed extremely satisfying improvisations in Austin, Texas with two new projects, *Cephalon* and *Velize*. I believe much of the satisfaction of this mapping has come through practice and playing with other dedicated improvisers. All the sounds on this recording below are of the guitar and violin being processed, looped and affected.



"Untitled Improvisation" by Cephalon (26/6/16)
https://youtu.be/uvZumq37kRw

Velize is a project based on degradation. The AirSticks are used to sample a simple drone on a synth played by the second performer. The second performer then begins to sample the sound created by the AirSticks, which in turn is sampled by the AirSticks and so on until the second performer decides to introduce further synth pads or until the improvisation comes to an end. This was a very fruitful process of improvising and listening and later editing improvisations for album releases. Much was learnt from each other from our different approaches to live sampling, me on the AirSticks and the second performer on *MPC*.

Velize albums (First release 17/5/16)
https://velize.bandcamp.com/

With some of the collaborations on the AirSticks it became apparent that the collaborators were less interested in doing improvisations but instead wanted the AirSticks to be used as a **tool for composition.** This was particularly the case in earlier projects where I was not as practiced on the AirSticks and had not developed the *Vacuum* template mapping to confidently improvise like in *Cephalon* and *Velize*. "*Drum Vacuum One"* was definitely one of the pieces where the AirSticks were used as a tool for composition. This duo with a drummer began with us improvising and not feeling like we were getting anywhere. Instead we found a theme we liked on the drum kit and recorded it. I took the time away from the rehearsal room to cut up the acoustic drum samples into a groove which I then learnt to play on the AirSticks over the original drum kit groove. We then arranged the piece together in the rehearsal room, resulting in this performance made up purely of the sound of that one drum kit.

"Drum Vacuum One (Amsterdam)" by Alon Ilsar & Gerri Jäger (11/10/13)
https://youtu.be/8uBD5bu_dEc

The "*Violin Vacuum One*" improvisation also inspired Bronwyn Cumbo and I to further investigate the AirSticks as a tool for composition in a duo called *Silent Spring*. The name *Silent Spring* is based on a book that many consider the start of the environmental movement. The name also conjures up images of a lifeless world. We composed and performed a piece called "*Dawn"* for NIME2014 that created the sonic narrative of the natural world being destroyed. We later performed this piece again at a leading venue in Sydney, the Basement.

"Dawn" begins with a similar drone as "*Air Vacuum*" using feedback of the room, but then as the violin begins to play quietly into the microphone, the violin and room unite. To help tell the narrative of the breaking of a new day, Bronwyn plays a birdcall on the violin, which I had pre-sampled on the AirSticks. I trigger it in response. She plays a second call, and I respond again. Our intention with this opening was to not only set the scene of the birds waking up, but to also display the relationship between the violin and AirSticks. Triggering the bird calls up high above my body, above the canopy, and only playing the same phrases as the violin, invites the audience to make a connection between movement and sound, and teaches them the workings of the AirSticks. But quickly we subvert this, with me leading the calls and Bronwyn responding. After the cacophony of bird sounds builds, a loop of the samples settles as the bed for the piece. Bronwyn then brings in the next section – a four-note pizzicato ostinato manipulated through a delay which forms a chord. This chord builds until I bring in a bass line version of the ostinato.

This four-note ostinato was in fact written on the piano. Later I sampled the violin and made a demo of a 5/4 groove with the violin pitched down to sound like a bass. Various percussive sounds were also cut up from extended technique playing of the violin. These were

used to make up the rest of the groove. I then learnt to play this groove on the AirSticks. Here I had many decisions to make as to how to map this groove to movement. I call this method of mapping **sound-first mapping**, meaning I have a certain groove or sometimes complete piece that is recorded and needs to sound as similar to the recording in the live performance. I will elaborate on this in Chapter 5: Discussion.

"Dawn" by Silent Spring (24/7/14)
https://youtu.be/M8rF0pbbpqY

At the time of "*Dawn"* I was still using the *Box* template mapping so I had to be very precise to play the groove correctly. Also, I had more samples to trigger than boxes, so I decided to allocate two samples to each box and for the z-rotation to control which of these two samples to play. This led to me making a figure eight motion to play the groove which gave the movement much flow. I have not revisited this type of movement since this project as the *Box* template mapping was soon replaced by the *Morph* template mapping.

The piece continues with Bronwyn bringing back the birdcalls as fragmented melodies over the groove as the whole sound is destroyed by a *Bit Reducer* effect in *Ableton Live*, until the only sound left is distorted feedback tones from the live microphone.

After an extended hiatus in 2015, *Silent Spring* performed two new pieces in a concert in New York in 2016 where the AirSticks were used, through improvisation, to compose and perform the following piece, "*Snowflake*." Again, this highlights a slightly different creative process through the use of the AirSticks which I will elaborate on in Chapter 5: Discussion.

"Snowflake" by Silent Spring (18/12/16)
https://youtu.be/97ALntmIKT0

Another well-documented piece involving the *Vacuum* template mapping with this process of sound-first mapping is another original piece, "*Vocal Vacuum One (aka Narcissus)*." The process of creating this piece began with the vocalist improvising melodic phrases on top of each other. I then cut these up in a similar fashion as in "*Dawn"* and created a dense groove that included several melodic fragments that could work on top of each other. I then learnt to play this piece on the AirSticks while adapting the mapping. Again, this is the part of the process I am calling sound-first mapping – making decisions on which movements should represent which sound through listening to a pre-composed theme. I decided to play the simple bass line with my right hand near my body, a snare like sound on my left hand where one would expect a snare to be, and keep long samples up high and wide away from my body. I did grapple with the use of these longer samples as they quickly cause a lack of **transparency** between movement and sound. Using the *Box* mapping meant I was stuck staring at the screen, particularly anxious not to miss triggering one of the longer samples. Once I had learnt the '**choreography**' of the piece, and was comfortable enough to improvise around the piece's main structures, I could add more layers of manipulation of parameters to the mapping which I kept changing as the piece developed in its new 'live' form. I sent a rough recording of the piece to the vocalist who wrote lyrics and melody to it. The lyrics in this case were in fact inspired by the theme of narcissism, based on what the vocalist felt when hearing a whole track made up of his voice cut up in several different ways. We then collaborated in the rehearsal room with these lyrics and melodies as the two of us re-arranged the piece and began to integrate the live manipulation of his voice. The 'score' was then left open for different interpretations during each live performance. Other pieces were also developed in *Malarkey*

through this approach, later integrating samples of water and incorporating live visuals. I will elaborate on these in the section dedicated to *Malarkey* shortly.

"Narcissus" by Malarkey (5/1/14)
https://youtu.be/AzQrqBjVA8Y

The *Vacuum Box* template mapping became the starting point for many projects as I continued to address the problem of sonic palette by sampling the musicians I worked with. The major revelation that came from working on *Silent Spring* and surrounding projects was that the AirSticks could be used as a tool for improvisation, composition AND performance. Working with different musicians called for these different uses and like with any instrument, specific patterns and exercises needed to be practiced. I was still paralysed by the possibilities of the AirSticks in this early stage, but realised that writing short motifs on a computer, learning how to play them, and then improvising with them was not only great practice, but also helped develop the instrument more quickly. Also, for improvisational gigs, finding the right balance between predictability and unpredictability in a mapping was a matter of much fine-tuning. I will discuss this in more detail in the next chapter.

4.4.3 Dark as a Dungeon (11/2013)

"*Dark as a Dungeon*" was a live score to an original short silent film by guitarist, electronic musician and singer, Kyle Sanna. One difference between this and a conventional live score was that the film and score were worked on concurrently. I again began with the *Vacuum Box* mapping as my template and built a very specific mapping from this. All the music for the short film was performed live. Unfortunately, most of the video I attained of this performance is just of the film itself so the mapping decisions I made do not reveal themselves. I also do not believe the film itself would cast any light on what I would like to reveal here. Even though the documentation is too poor to include in this thesis, I wanted to include this case study because I had three major revelations from working on it.

Figure 20. Screenshot from the "*Dark As A Dungeon*" Film

Firstly, I realised that through some rehearsal of a composed section, I could reliably record and trigger desired samples. To time and execute this recording with more control I employed a more discreet mapping of using a button on the controller to record, instead of the grand gesture I tried using in "*Drum Vacuum One*." I returned to enabling this feature in later *Vacuum* mappings. The idea of instructing the acoustic musician as to when s/he was being recorded was relegated to a figurative gesture, for example a nod or raised eyebrow. By cuing the guitarist to play a slowly plucked chord, I could time the pressing of a button to grab the last note. I would then play this last note, repeated in a short loop, by pushing downwards through the x-rotation, turning the volume of the sample up as I pushed down further. This led to a meaningful relationship between the sound and movement, like I was pulling on a string attached above to generate more sound.

This section of guitar manipulation in the piece led to another section where I was

putting heavy reverb on the guitar as I moved my hands high and wide. I mapped the reverb this way because the specific section of the film featured shots of grand open mountain ranges of Alaska. It seemed fitting to perform this big gesture with the AirSticks to go along with the long reverb sound and the vast mountain range. Similarly, there was another scene in the film where the characters go down a mineshaft. For this section I took samples of rocks falling down shafts and triggered them close to my body, taking up as little space as possible. I am calling this form of mapping, visual inspired mapping, where some kind of visual stimulus inspires a type of movement, whether from another performer or from visuals or video like on this occasion.

The third revelation was a very pleasing and simple one. When interviewing Kyle about this project I asked why he had asked me to collaborate with him, thinking that he had chosen the AirSticks for their ability to add something different and novel to the performance. This was definitely true, but of more importance for Kyle was that he simply wanted to work with me. He knew little about the AirSticks, but was confident that I would bring satisfying results from our previous collaborations where I played drums. This brings me back to the importance of designing new instruments for more collaborative contexts across both the improvising and composing streams of music. This will not only help promote the culture of new instruments more rapidly, but through the process of observing collaborators, we can design better instruments for high-level social interplay. I will return to this concept in the subsection **mapping for ensemble playing** in Chapter 5: Discussion.

In summary, this piece revealed that mapping can be inspired by a visual stimulus, discreet gestures are sometimes necessary in creating the desired mapping, and social interplay and collaboration is often the most important factor in working on a project.

4.4.4 H2.0 (11/2013)

This project began with the desire to make an audio-visual piece with some sort of narrative. Mark Bolotin's creative practice as a visual artist and musician had led him to create the *Lumiphonic Creature Choir (LCC),* a giant twelve-headed structure that comes to life when twelve faces are projection mapped onto it. Up to this point in Mark's practice, he had interacted with the *LCC* through a piano keyboard, often positioning himself in front of the structure, facing forwards. He wanted to communicate the relationship between him playing the keyboard and the various giant heads singing behind him, but the minimal movement of pressing a note on the keyboard did not sell this connection very well nor did it create much transparency. He would often play with a full band, and have the drummer use electronic pads to trigger the heads to sing. Again, this did not make for a very strong connection either.

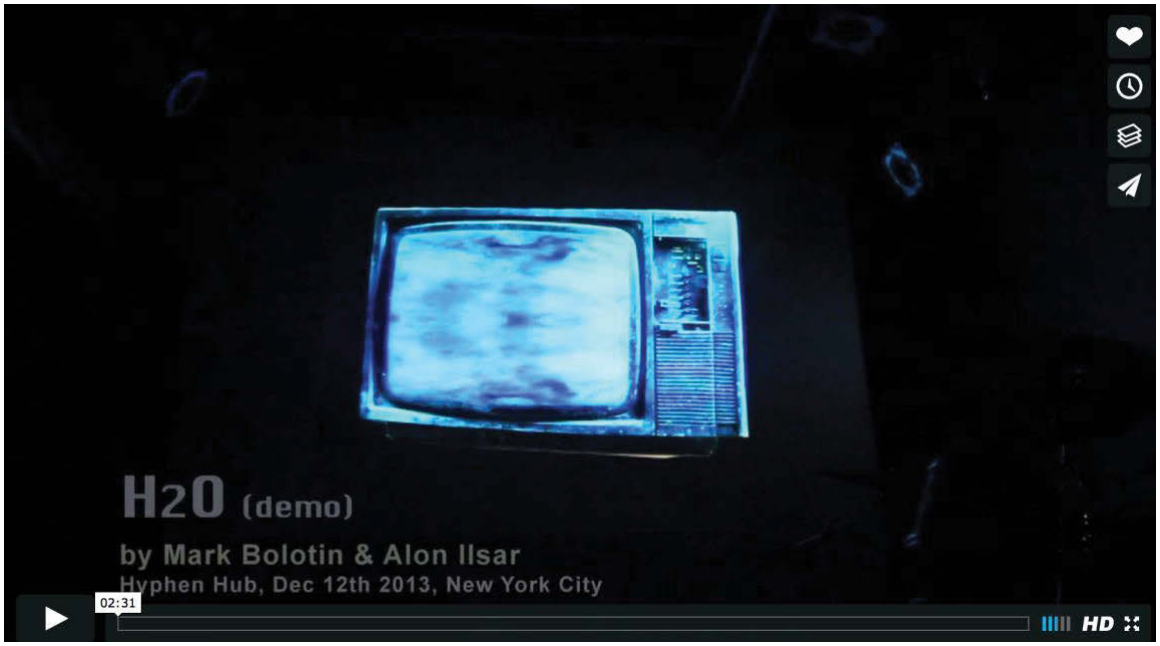
I approached Mark with a proposal to 'conduct' the *LCC* with the AirSticks; to stand in front of the structure, back to audience, and trigger the different heads as I pointed at them. In this way, this project could be thought of as inspiration from movement first, what I refer to as **movement-first mapping**, in opposition to the aforementioned sound-first mapping. The question of 'how to move?' takes precedence over 'what sound to make?' Again, I will elaborate on this further in Chapter 5: Discussion.

In "*H2.0*," we experimented with various positions of note on/off in the **playing space** around me and finally settled on a triggering system. This wasn't ideal as the note on was detected by striking the air in an xyz field around me, and not by where the controllers were pointing. Through practice, however, we managed to make it look like I was conducting these giant characters. It did make it very hard to play any kind of percussive music, but we persevered.

Having created a working system, we needed to write the piece – we had booked a performance in with little time to develop and rehearse what became a very ambitious project.

We were both very interested in exploring narrative, and giving the heads a life of their own. We wanted the piece to evolve somehow. We decided we wanted to investigate the concept of water, from the perspective of sound and visuals, but also to express its necessity for life, its shifting states and its scarcity in parts of our world. We wanted to communicate the story of our earliest ancestors coming from the ocean, and wanted to ask where our relationship with water was going, and what water's role would be in the future. We wanted to investigate notions of determination and free will, and of singularity and robots enslaving humans.

We came up with a simple structure to present all of these thoughts. Unfortunately, during the performance the laptop running the visuals crashed and I was left on stage still playing sounds but with no visuals. We salvaged a short demo video of the piece for your viewing here.



"H2.0" by Mark Bolotin & Alon Ilsar (12/12/13)
https://vimeo.com/83406035

The piece began with the *LCC* heads slowly being filled up with steam. This steam, over music from a backing track, turned into water as the sound of playing wine glasses faded in. Once these giant glasses were full of water of varying levels, I, as the conductor, walked out and began to 'play' or 'conduct' the instrument by pointing at different vessels. For this first section, drops and splashes were used to create rhythmic patterns. Occasionally, the vessel was triggered to fill up with water. Once all the vessels were full of water, the next section began. This next section was based on a short melody I had written on piano that was 'sung' by the faces emerging from the water vessels. After a short while playing this melody, the heads started to sing the wrong notes, discreetly triggered by me pressing a button to change the scale of the piece. Eventually the heads make a cacophony of sound which I stop by turning all the vessels into ice. After a moment of silence, I try again to control the giant heads but there is no response, having used another button to mute the sound. Eventually, on another button press, the heads retaliate, causing an electric shock that makes me drop my 'batons.' The heads continue to sing a mechanical drone as I become one of them, turning and facing the audience, giving a robotic bow.

This piece was way too grand to pull off in the short amount of time we had. Since the piece led with a narrative and structure, and not with the sound, we ended up being very frustrated by the piece's sonic qualities. It did not come up to scratch. In fact, we were not proud of any element of the piece other than the fact we did put it together in a short time, and we did like the concept and the idea of the narrative.

I felt with this piece that many of the strengths of using the AirSticks were lost because I had to 'sell' the act of conducting this virtual choir. The subtleties of the movement were lost

as the **theatricality** of conducting took over. I tried to create expression from what little movement there was left after triggering each sound, but I still had to look at the screen to trigger in the correct box. This became all too much for me in the short amount of time.

My original idea for the "*H2.0"* was to base the main theme of the piece around a rhythm I had composed on the drum kit, but it was amazing how much harder it was to play on the AirSticks than on kit, most probably due to the lack of **haptic feedback**. I will discuss ways of dealing with this shortcoming in Chapter 6: Future Work. I ended up scrapping this rhythm for "*H2.0"* due to the time constraints of the project but also due to the fact that the conductor metaphor did not lend itself to incorporation of the feet in playing this theme. I did revisit this rhythm on the AirSticks later and wanted to include it here to display the importance of practice in the mapping process. It was through much practice that got playing this rhythm to a comfortable place on the AirSticks. I eventually turned it into a solo piece intended to be expanded for the *Faulkland* project.

"Faulkland Raga Solo" by Alon Ilsar (12/1/14)
https://youtu.be/zXfVKvYDuHk

At this point of the AirSticks development I was still using the *Box* mapping but I was already much more comfortable triggering percussive sounds and playing precise complex patterns. To fill out the sound further in "*Faulkland Raga*" I layered the kit sounds with two synths and effects. I could switch these on and off with different buttons and change the pitch of the synths with the thumb joystick. This relatively sparse groove gave me the space to use the buttons more freely, and focus on note length and the manipulation of these **sustained** sounds.

In some situations, I practiced rhythms that left no space for button presses or manipulation of longer sounds. This next short example of a groove, "*Faulkland Bounce,*" also intended for the band *Faulkland*, probably needed the most practice to learn and play.

"Faulkland Bounce Solo" by Alon Ilsar (12/1/17)
https://youtu.be/5MxwP5gq57g

I wanted to include this video excerpt to highlight that over the course of developing the AirSticks, I decided to play to certain inherent strengths and weaknesses of the instrument. The major strength for the instrument was the control over long sounds across xyz position and rotation, button presses, finger triggers and thumb joystick, and the morphing of these sounds in a continuous manner, as opposed to samples being assigned to discrete points or boxes in the playing space. The major weakness of the AirSticks is playing it like a drum kit. Having no haptic or tactile feedback meant that playing as fast as on pads was simply not an option.

Since I was limited by the conducting metaphor in "*H2.0"* I decided to trigger longer looped phrases of drips and drops. This helped, in this solo context, to fill up the piece sonically and the vessels visually. Again, like discussed in the section on "*Air Vacuum,"* this use of loops was not my intention with the AirSticks, although using visuals does give the loops more transparency than without visuals. I decided to make the patterns simple pulses, like a leaking tap that had been left on. In later projects, I began to trigger more complicated rhythmic patterns than a simple pulse and manipulate these patterns with other gestures. I will discuss this concept later in a subsequent case study.

The mapping for "*H2.0"* was what I described at the time as 'micromapped.' The *Ableton Live* session was extremely specific and particular to this piece, very removed from any

original template mapping. I would not use this mapping as a basis for any other mapping, unlike *Vacuum* mapping for example, which I would continually come back to in new projects.

One thing I did consider after doing this piece, and after the technical difficulties and lack of satisfaction with the music itself, was doing the piece again as a pre-recorded audio-visual experience, focusing on the visuals and music, and asking an actor to **mime** the role as conductor. How would this change the experience for the audience? And for the composers and performers? This is a concept I will elaborate on throughout Chapter 5: Discussion.

Overall "*H2.0"* was the least fulfilling project that I was involved in with the AirSticks though there was a lot to learn from this experience. I soon after realised that the *Box* mapping was playing heavily against the strength of the AirSticks being a continuous open-air controller. The experience also made me want to put more emphasis on the actual music created and performed with the AirSticks and get away from the narrative or conceptual inspiration. In "*H2.0"* I placed too much importance on theatricality, making it too difficult to **efficiently** use the AirSticks to create and perform music I was happy with. My experience from "*H2.0"* also inspired me to look for a more sophisticated relationship between the AirSticks and visuals – to visualise more elements of the AirSticks movements instead of simply triggering a short visual clip.

4.4.5 Malarkey (3/2014 -)

Before I went on to solve many of the mapping problems with the AirSticks that came up in "*H2.0*," I used this visualisation system in collaboration with Des Miller under the moniker of *Malarkey*. We wanted to make a music video for our song "*Narcissus"* and decided to collaborate with Mark Bolotin and his *Lumiphonic Creature Choir*. Mark had been offered to take the *LCC* to the South By South West (SXSW) Festival in Austin, Texas in March 2014. We had under a month to prepare a 30min set. We played this set at a showing in an underground venue in Sydney, and then at the Museum of Contemporary Art (MCA) before heading to Texas. We then filmed a performance in NYC.

Our first significant decision with this project was to use the *LCC* as a backdrop, and compromise much of the connection between the AirSticks and the visuals for simplicity's sake. Each vocal sample was mimed by Des in front of a camera, and these visual samples were mapped to the appropriate MIDI note on the AirSticks that corresponded to the sound. Again, this was quite a primitive one-to-one mapping of the AirSticks movements, but was successful in creating the desired effect of Des and I being supported by a group of floating heads. We later also introduced some of the samples used in "*H2.0"* of water and ice cracking to expand the palette.

"See" by Malarkey & LCC (21/3/14)
https://vimeo.com/103199272

"So It Goes" by Malarkey & LCC (21/3/14)
https://vimeo.com/101525660

We decided that I should wear some lights on my wrists and feet as the *LCC* looked best in the dark. Mark also added another layer for visuals on top of what I was triggering. I liked this a lot as it gave the visuals a life of their own at times, and allowed the pieces to build beyond the simple immediate connection of the AirSticks to the visuals.

This was a much more satisfying project than "*H2.0"*, and felt like a much better use of the *LCC*. After performing these pieces, I yearned to find a new palette to work with on the AirSticks, to get away from acoustic samples, and to find a way of sustaining sounds so that I would have more time to augment them.

4.4.6 Nine Lives Live (8/2014 -)

This solo performance was the first since the Creativity and Cognition Conference performance a year earlier and was performed at the Creativity and Cognition Studios as part of a day of talks and performances.

"Nine Lives Live" by Alon Ilsar (21/8/14)
https://youtu.be/_4d1nRrPV9U

For this performance, I did not want to sample my environment, but instead wanted to have all the sounds pre-loaded. I had been experimenting with **Frequency Modulation (FM) synthesis** in *Ableton Live* but could not figure out how to utilise it meaningfully within the *Box* mapping system. The breakthrough occurred when I realised that instead of sending different MIDI notes for each box from the *Custom AirSticks Midi Software*, I should just send one MIDI note for each hand, what we now call the Global Hand function. Each MIDI note would trigger several synths components in *Ableton Live*. The xyz position would change the volume of each of these synths components. For example, having my right hand forward, left and down would mean that the volume of one synth component would be at its maximum, and as I shifted either back, right or up its volume would fade down as a different component of the synth's volume would fade up. These components were chained in series to add to the complexity of the sound. As mentioned earlier, other instrument developers have created much more complicated algorithms for sound morphing, including Mark Havryliv. I will return to this idea in greater detail in a section on future software in Chapter 6: Future Work.

Hand	Movement	Parameter
Left	x position	Synth 1 OSC B Vol
“	y position	Synth 1 OSC C Vol
“	z position	Synth 1 OSC D Vol
“	x rotation	Synth 1Volume
“	y rotation	Synth 1 Panning
“	z rotation	Synth 1 Filter
Right	x position	Synth 2 OSC B Vol
“	y position	Synth 2 OSC C Vol
“	z position	Synth 2 OSC D Vol
“	x rotation	Synth 2 Volume
“	y rotation	Synth 2 Panning
“	z rotation	Synth 2 Filter

Table 4. Movement to Parameter Mapping for “*Nine Lives Live*”

I used the x-rotation trigger system as the main system for switching sounds on, but I also developed two further methods. By holding the trigger button down, I could also trigger several synths which were also assigned a volume according to the xyz position of my hand. In this case though, it would chop the sound up into a pulse, with the x-rotation controlling the rate of this chop – faster as I pushed further down. This allowed me to create interesting counter pulses between the two hands. I could also trigger a synth sound by holding the rectangle button with a slow attack and release, its overall volume being controlled on the x rotation. This allowed me to fade sounds in, using the metaphor of bowing more than of striking. Lastly, the feet would trigger whatever sound the hands were generating, depending on their xyz position, with the right hand controlling the right foot or bass drum sound, and the left hand controlling the left foot or snare sound.

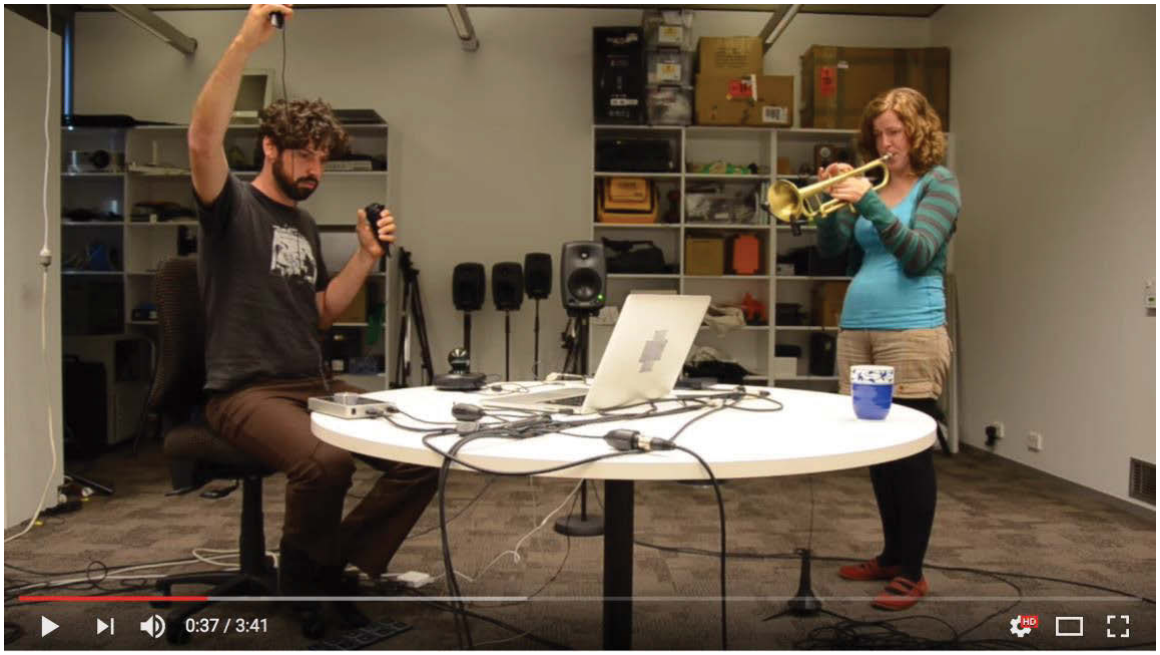
We also created ‘safe zones.’ Anything left of the centre for the right hand sent out midi number 0, and anything right of centre for the left hand sent midi number 127. This meant I rarely crossed hands (because there was no new information or sounds to trigger there), but also meant that I could reliably trigger certain sounds in these zones.

All these options to play a very limited palette made for a very different compositional process. Having a strict one-to-one mapping and no sound input of other less predictable instruments or feedback tones meant I could focus on creating a structured piece that explored the space in different ways with a defined palette. With “*Nine Lives Live”* I wanted to start with transparent dramatic gestures and then ease into a more minimal section exploring the space with circles, starting with small circles on one axis and slowly enlarging the circles and changing their axes. This gave me the feeling similar to that of playing brushes on a snare drum, but in a 3D playing space. Indeed, I had several comments from audience members making these comparisons, most notably from a former drum teacher.

This mapping really captured the essence of open-air controllers in that there are no discrete spaces but instead one fluid continuous space. This not only liberated me from watching a screen but changed the way I approached the instrument. I felt I could improvise and explore the space more freely and indeed my next project with this new *Morph* mapping was a structured improvisation with a trumpeter, combining this new mapping with the *Vacuum* template mapping.

4.4.7 Duo with Ellen Kirkwood (10/2014)

In September 2014, I was approached by trumpeter Ellen Kirkwood to perform a duo with her at a Sydney jazz club. Ellen was aware of the possibilities of the AirSticks and has collaborated with me in several different contexts throughout this project, including writing music specifically for the AirSticks. This performance with Ellen was my first attempt at combining the *Morph* mapping with the *Vacuum* mapping, not only allowing me to manipulate the sound of her trumpet but also contribute my own synth sounds into the mix. This created more of a two-way conversation with me not only throwing Ellen's sound back at her, but also exploring a synth palette. This further inspired Ellen to bounce off and deal with the synth sounds and throw ideas based on those sounds back at me. Here is an excerpt from an improvisation we did while preparing for the gig.



"Untitled Improvisation" by Ellen Kirkwood & Alon Ilsar (23/9/14)
https://youtu.be/PKtO2MVh6Oc

We found ourselves, through playing around improvisational concepts, creating a series of structured improvisations. For example, the performance began with an improvisational concept we called 'opposites'. We would improvise a long phrase together and once we felt it was complete we would cue each other to move on to improvise another long phrase together. This next phrase needed to be the 'opposite' to the one before, however we interpreted that, as would the one that followed it. We could not repeat any of the moods previously played and hence we needed to explore the sound in as many ways as possible.

We also explored the idea of sounds as characters. Moving my left hand back and forward changes the time of a delay placed on the trumpet. Keeping the feedback high through pushing the thumb joystick forward allowed me to basically freeze a high-pitched tone created

purely from the trumpet that ended up sounding like the sound design used for the space ship control room. Ellen and I were then for some reason inspired to imagine that a frog had been let loose in this control room (played by the trumpet), and was being chased by a little mechanical robot (played by the AirSticks playing rhythmic patterns that turn into tones as they are sped up).

Most evident in the excerpt used here was the use of freezing the reverb of the trumpet by striking the air up high to my right, and then being able to filter that sound by rotating the wrist on the z-axis. This was a metaphor I kept for most mappings, this turning of a filter sweep felt intuitive ever since the *Air Vacuum* project. The use of a frozen reverb effect, otherwise known as spectral freeze, also became a staple in most of my mappings as I continued to explore ways of sustaining sounds on the AirSticks in a meaningful way.

The relationship of the AirSticks to physical movement allowed Ellen and I to explore these kinds of improvisational concepts in a similar fashion to an acoustic duo, but with a palette of an electro-acoustic ensemble. Putting the exploration of electro-acoustic improvisation aside for a while, my next major breakthrough with the AirSticks was the use of the trigger button to play metronomic rhythmic patterns.

I have kept using this mapping in new projects and also in later *Silent Spring,* provided here to show the development of the mapping and the more comfortable playing of it.

"Cave" by Silent Spring (18/12/16)
https://youtu.be/8aqup3SDJ9k

4.4.8 The Sticks Dock Residency (11/2014 – 1/2015)

Upon reflecting on these previous projects at the time, I realised there was another strength I wasn't playing to: my skill set as a drummer. I formed a more 'conventional' trio, *the Sticks*, featuring keys, bass and AirSticks, and set out to focus on playing the drummer's role in this project, concentrating primarily on the rhythmic elements of the music. This allowed the other musicians to focus on their respective elements of the music and meant we could build on a long 'jazz' trio tradition with a completely different sonic palette. We aspired to improvise, compose and perform in similar ways as we would have in an acoustic trio, and to allow guest performers to easily join us in our music making.

The Sticks' first gig under this name was on November 4 at a small bar in Redfern, Sydney. We went on to play there every Tuesday for three months, with many other gigs coming out of this residency. The intention of *the Sticks* was to make beat oriented electronic music, ideally improvised. I had had several previous projects with these musicians, and all of them were in the band, *Faulkland,* which featured earlier mappings of the AirSticks.

On the first week of the residency we invited guest another synth player to join us. We had a couple rehearsals with this line up. I brought some tunes to cover at the residency, and rehearsed some conceptual improvisations similar to ones explored in the duo with Ellen Kirkwood, where a rough concept or instruction was alluded to. For example, some instructions were, 'don't play when everyone else is playing', 'only play three ideas for this 5-minute piece,' 'adhere to the structure of ABABC' and 'simply play for 20min and stop.' In our first show, however, the band never ended up playing any of these tunes, or the conceptual improvisations. We just enjoyed improvising freely too much.

For *the Sticks'* residency, I created the *Ultimate Morph Vacuum* template mapping that was a combination of previous template mappings, taking the mapping used in the duo with Ellen Kirkwood as a starting point and adding to it a layer of sampled drum sounds that morphed in a similar fashion as the synth. This combination of mappings quickly became my template mapping for most projects as it gave me such a large range of options. Due to computational limitations though, I did need to simplify the mapping somewhat to keep *Ableton Live* from crashing. Already the graphics in *Ableton Live* were lagging immensely, and the sound would occasionally clip and crackle. I decided to ask a little less of my computer by taking out some plugins.

The intention of the mapping was to allow me to predictably play beats with more typical electronic drum sounds, unlike the *Vacuum* mappings where it was a guessing game as to what sounds would come out. I also incorporated the percussion *Arpeggiator* (*Arp*) system to play more robotic fast beats with subtle movements while still being able to play kick and snare patterns with larger movements. Here is the earliest example of this sort of mapping back from late 2013.

"AirSticks Improv using Konkrete 1" by Alon Ilsar (19/9/13)
https://youtu.be/3HbUnUCOxck

Throughout the 12-week residency *the Sticks* improvised freely each week with different guests, with the very occasional cover, which were most probably the lowlights of the residency. The improvisations just felt really fresh and exciting. Most of the twenty-four 40-50min sets were recorded and revisited. A few ideas from these recordings were brought to a recording session *the Sticks* did after this residency. By the time of the recording session the residency was over and the band had got some other gigs in other venues in Sydney. One of these gigs was reviewed very highly by a local online blog, describing the band as 'Innovative, moody and enthralling… beyond the realm of a standard electronic band. Their live show alone is a revelation.'[55]

The most well documented performance we had was a performance at the Sydney Opera House for TedX Sydney. This was an extremely nerve-racking affair. A little anecdote about this performance was that it came up very quickly for us. I was meant to perform at TedX Sydney with another musician, a Djembe player, in a performance that was meant to showcase the old and new worlds of percussion coming together. I worked frantically on preparing for this duo but 24 hours before the performance the Djembe player fell ill and had to pull out of the performance. I suggested that I do a piece with *the Sticks*, and the organisers agreed. Luckily the other band members were free. We had just recorded our album on a band retreat just outside Sydney but most of the pieces were very under rehearsed. We chose a track that we were about to release as a single. We had only performed it live once before. We rehearsed it up with the band, expanding it into a 5-min piece and arranging an AirSticks solo into it. I was

[55] For review visit http://hhhhappy.com/the-best-electronic-band-in-sydney-the-sticks-are-a-top-contender/

nervously preparing for performing this piece in the dressing room when I realised that I could warm up for the performance by miming the entire piece whilst hearing it in my head. I had already discovered from our residency that I felt physically more in control of the instrument after some warming up, so I wanted to warm up for this 5-min performance as much as possible. Both the keyboard player and bass player caught me in the dressing room air drumming away, and could tell from my movements where I was in the song. They joined in, miming their parts, and we re-rehearsed the piece from the top in this manner, perhaps more for comradery than actual practice.

We got our cue to go out and perform our piece. We had sound-checked earlier and knew it would be stressful to roll us out again to play. There were major issues getting us ready to perform, not from our end, but from the Opera House's end. The MC kept covering for us as we waited for the issue to be resolved. Finally, after what seemed like hours sitting on the Concert Hall stage waiting for the cue to start the piece, we were given our final introduction. I started to play… no sound on stage. Somehow our monitors on stage were not working and we had to rely on hearing our electronic instruments from the front-of-house PA system metres in front of us and pointing out into the audience. Luckily, we had just practiced miming the piece. So what you see and hear here is a band, with an air drummer, holding on for dear life in the hope that they are all in the same part of the song.

"World Maps" by The Sticks (21/5/15)
https://youtu.be/WbtQ9zKkhyc

In summary, *the Sticks* Dock residency made me focus more on my role as a drummer in an ensemble, and on the different approaches between improvised and composed performances.

4.4.9 The Sticks Debut Album (2/2015)

This album was recorded over 5 days in Bilpin in the Blue Mountains west of Sydney and was reviewed by the Rolling Stone magazine and Garbed Wire.

'by album's end you've been sucked through a black hole… and spat out the other side into David Lynch's darkest nightmare.'[56]

'The Sticks self-titled debut album is excellent… Each track sounds like the workings of the brain, the buzz of inspiration, electric idea cells sparking, blood racing through your veins and pulsating around your heart.'[57]

Most pieces were conceived during that period, other than a couple of ideas from improvisations we had made earlier. Some pieces were purely improvised from conceptual ideas. The AirSticks, four synths, bass through effects and a room mic were recorded directly onto a computer. The AirSticks, bass, another room mic and the mix of the synths was also recorded onto my computer along with all the automation within *Ableton Live*. Essentially all the movement of the AirSticks was recorded and could be edited later. This gave us the ultimate control in the mixing process, allowing us to fine-tune panning, velocities, replace samples, and even move the timing of MIDI notes. We explored using these automations on other effects too, in a sense **post-mapping**. This was interesting as the literal movement of my playing could later be assigned to completely different sounds, for example the x-rotation of the right hand could also be assigned to control the volume of a keyboard during mixing. We did not use this to great effect but we did learn a lot from this type of post-mapping and reintegrated it back into the system. Having heard how the mapping sounded through listening back, I later started to in fact map my movement to control the volume of the keyboard in live performance in a similar way.

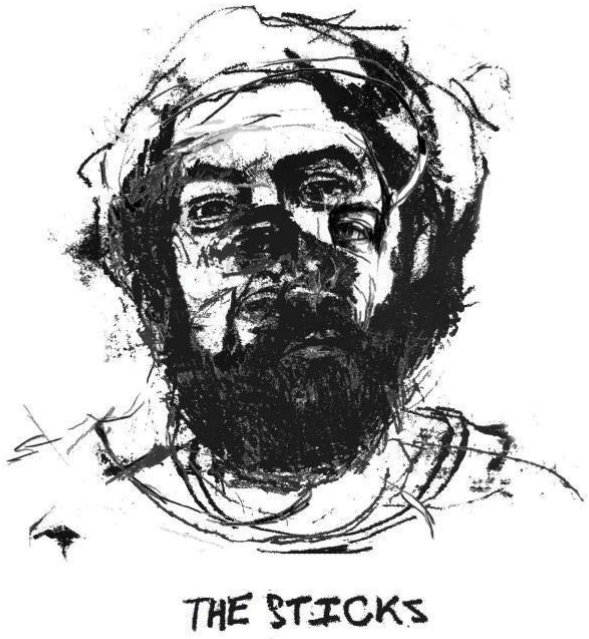
Although recording only took 5 days the mixing process took much longer, with around two mixing sessions a week for 2 months. For this mixing process, we were joined by an experienced sound engineer who specialises in using *Ableton Live*. He was particularly interested in the approach we had taken and put a lot of creative energy into the project.

The AirSticks automation was also used to help create the visuals for music videos for two of the tracks on the album. Here below are links to and these two clips and the entire album.

[56] For full review visit https://rollingstoneaus.com/reviews/post/the-sticks/2714
[57] For full review visit https://thegarbwire.com/2015/11/11/the-sticks-debut-album-out-now/

"World Maps" by The Sticks (Recorded 12-16/2/15)
https://youtu.be/J1mr472SOdw

"Sidestep" by the Sticks feat. Jane Sheldon (Recorded 12-16/2/15)
https://youtu.be/SnpTFW-6804



The Sticks Debut Album (Released 6/11/15)

https://thesticksband.bandcamp.com/

It Follows You

This track focuses on sweeping sounds around the stereo image, attempting to create the feeling of floating peacefully in space. This sweeping and panning increases in intensity as the track continues. The chord movement grows further away from the original key centre, first by only playing the first two chords of a long cycle, then four, eight and finally the whole cycle. Circular movement with both hands mimic the playing of brushes in a jazz ballad, as white noise is filtered and manipulated to create a slow rhythm. Since each parameter is mapped to a straight line, circular movements mean that several parameters shift at the same time, including panning, filtering and volume. Added to this, the audio signals from the other instruments are also panned and filtered and put through changing reverb, distortion and delay. Making larger circular movements and shifting their axes allows the sound to build and morph. Additional effects were added onto this track during mixing, and various automations from the AirSticks were used to give these effects further movement.

Deep Fried

This track was edited from an improvisation. The concept of the improvisation was to start playing a groove all together without counting in. All that the musicians knew before playing was the key the groove would be in. In the mixing process, we then replaced some of the samples, doubled some of the keyboards and looped one of the sections. We also edited the intro block of sounds from another improvisation. When playing this tune live now, we extend and change it further. We wish we had rehearsed this song more before recording. The process

with the covers for the next recording was much more about re-rehearsing the material, not just trying to fix them in the studio. Having said that, there are pieces on this album that we will probably never play live.

"Deep Fried" is an attempt at making a **wonky beat** track, a hip hop beat that is off the grid, in between a straight and swung feel, keeping space for each individual sound. Our intention was to create a pocket of sound, a burst of energy coming out of the floatiness of the opening track. This kind of feel is a specialty for the AirSticks, giving a human feel to the attack, sustain and release of the electronic percussion and allowing the rest of the band to watch and listen for cues as the groove is pulled and stretched in and out of time.

World Maps

This is possibly the most arranged track on the album. Sparked by the bass line, we quickly wanted to give it a video game edge, and after several attempts at different feels for the main section, we settled on a backbeat with busy non-repetitive metronomic flickered percussive sounds. The track begins with a free delay manipulation of the keys playing the opening chord, settling into the tempo of the piece. The bass and keys respond to each other as if they are conversing, until they come together in the B section. In this B section the cymbals and reverb on the keys are linked, getting panned and filtered together. We also did many keys overdubs. The C section came out of us improvising around some hits, eventually using them to go into a 6/4 feel that builds to the end. The *Arps* function is flicked to free time which makes the rhythm speed up and down on the x-rotation, giving a bouncy feel with each snare hit.

After Hours

This is an edit from an improvisation. The concept for the improvisation was that each musician would play a solo and would then be joined by another musician playing a completely different idea. Like in the opening track, the AirSticks were used as futurist drum brushes playing a virtual 3D drum skin.

Sidestep

This idea came from an improvisation we recorded at a live gig. We relearnt and rearranged it around the mysterious-sounding looped bass line. The AirSticks play a simple slow kick and snare pattern that allows time to slightly twist and turn each strike in a different way, giving it a human feel. During the mixing process, we did find that some of this manipulation of samples, especially of the kick, needed to be tightened. Conventionally, electronic percussion in electronic music of this kind is very precise, and although we wanted this track to not sound robotic, we ended up containing the sounds to smaller changes in parameters of panning, filtering and pitch. We also wanted a bigger kick sound, and ended up sampling it from a Boards of Canada track. For ambience, we added a recording of the night sounds from outside the studio in Bilpin and faded them in and out with the x-rotation of the left hand. These blend with the white noise synth noise that is triggered with each kick and snare. Finally, we invited soprano Jane Sheldon to improvise some ideas over this track. These were cut up and put through various effects, some controlled by the automation of the AirSticks, most noticeably

through the *Chopper*. We put these vocals through the same *Chopper* that was creating rhythms out of the white noise, again in an attempt to blend these sounds.

Mirage

This track was also inspired from an improvisation at a live gig and is inspired by the beats of producer *Madlib*. The night sounds from the previous track filter out with the movement of the left hand's x-rotation. Like "*Deep Fried*," this track has a slight wonky feel, but with a bit of drive given by the hi-hat pattern. How to make the hi-hat feel best is still mysterious to me. For some reason, different hi-hat samples do 'feel' very different. The live footage with a rough mix of this track can be found here

"Mirage" (Live in Bilpin) by the Sticks (14/2/15)
https://youtu.be/4n6fLf1zdug

Level Up

Inspired from playing around another wonky beat groove and keys melody, this piece's AirSticks track focuses on shortening and lengthening the snare, and again playing in between a straight and swung feel. I found this was a much more difficult pattern to play than it sounds, by nature of the swung foot pattern not usually played on a drum kit.

By Degrees

This idea came from a bass solo performed at a previous gig and some feedback manipulation I was doing in the room with a microphone. The opening is an AirSticks solo controlling feedback in the room with distortion, redux, reverb and delay like in "*Air Vacuum*." Eventually the bass plays a Spaghetti-Western style theme that returns on the keys later on. The main

ostinato on the bass, which sounds more like a guitar at this point, inspired by *Tortoise*, *Portishead* and *Boards of Canada*, begins a 7/4 feel and a three-chord pattern. This invited the rhythm to have a 3 and 7 pulse in it, which surprisingly did not take much practice on the AirSticks. This showed again that speed may be a problem with playing the AirSticks, but precision is not. Like in "*Sidestep*," the slow kick and snare pattern, which is doubled with the drum synths, gives time to execute variations of note length and timbre in each strike.

Machine with Concrete

This came from an AirSticks idea of slowly morphing a groove, stretching and squashing different cells of the pattern, reinventing the way the listener could interpret where the start of the bar is. Originally bass and keys did improvise over the drum pattern, but none of this was kept. All that was kept was the MIDI note values which included velocity and note length of the AirSticks, and the automation of the continuous controller changes, and again these were post-mapped to new sounds. The bass player wrote a melody for this piece. The producer and I made a MIDI score of this melody and used the MIDI notes from the right hand to play the rhythm of the bass line. This track was very much produced, coming into the studio with nothing but the automation of the AirSticks. We have not attempted to play this live.

The live footage with the final mix of this track can be found here. Note that some of the sounds of the AirSticks were automated to fade in for the final mix, and that the other instruments are muted. The video is also cut short because we looped a section for the final mix.

"Machine with Concrete Demo Vid" by the Sticks (15/2/15)
https://youtu.be/Lwl_37asHpQ

Receive Your Host

This is the sequel to the opening track and features the *Arp* function of the AirSticks like in "*World Maps*." The bass and keys parts were cut up and made to fit a performance of the AirSticks part which builds and develops into an onslaught by the end. We added a four-on-the-floor kick pattern to drive the piece further towards the end. We encountered a problem with the *Arp* being too busy when played by both hands and hence messed about quite a bit with some sounds in post-production and again some post-mapping to make space in the track.

In Secret

This is a solo AirSticks track cut up from improvisations made at Bilpin with feedback, similar to early *Air Vacuum* pieces.

There are many revelations to take from *the Sticks Debut Album* project including considerations of genre-specific mapping and mapping for an ensemble, but with so many shorter pieces going through the full composition process, most from their beginnings as improvisations to mixing them for the record, this project also helped me refine mappings and pay closer attention to the sound of the instrument, as opposed to the movement.

4.4.10 The Sticks "Visualised" (4/2015 -)

The Sticks "Visualised" is the current pinnacle of the AirSticks project, and sets *the Sticks* apart as a live act from conventional trios beyond the electronic sonic palette. I do not want to go too deeply into this project as here, as it opens up discussion about visualisation well beyond the scope of this thesis, but there were some interesting mapping considerations that came from working with such an interactive flexible visual system.

Musically, the 40-50 min set is mostly made up of songs from *the Sticks* debut album, but though the album itself was partly improvised and all performed and written over 5 days, these songs developed largely after the recording, both in the rehearsal room and at live shows.

As mentioned above, the band picked two singles from the album, "*World Maps"* and "*Sidestep*," and filmed music videos for both on the same day. The music videos featured the visuals used in our first trial run of *the Sticks "Visualised"* on April 16. We relearnt and rearranged some of the tunes from the album and performed extended free improvisations to make up the rest of the set. Here are the highlights from this show.

The Sticks "Visualised" Highlights from Lamps (16/4/15)
https://youtu.be/mDKJltHZtXU

We realised that for this show to work better, we needed the band to be more visible and for there to be less improvised sections. In June 2014, the Sticks did a tour of Melbourne, and spent the daylight hours before the series of four evening shows rehearsing songs from the album and writing some new material for *the Sticks "Visualised"* show. We inserted these tunes into our improvised sets on those evening shows in Melbourne. This gave us the option to either completely improvise, or, if things weren't feeling great, bring in an original. This meant that by the time we played *the Sticks "Visualised"* again in July we had some new tunes and some

new arrangements of tunes from the album. We improvised a lot less with the visuals by the time we did *the Sticks "Visualised"* again in July.

We developed the show further still and played completely composed performances in Melbourne and Sydney over the summer of 2015/16. Here are the highlights from this last show.

The Sticks "Visualised" Highlights from the Red Rattler (28/1/16)
https://youtu.be/GLbbWzlhMVc

The visuals for the show were created by Andrew Bluff and Andrew Johnston and are projected onto a scrim in front of the band. Half the visuals use Andrew Johnston's particle fluid simulation which takes the audio from the keys and bass to create the particles (Johnston 2013). The program then takes the AirSticks' xy position to allow the performer to in essence swim through the particles. The other half of the visuals are created through Andrew Bluff's *Storm software* (Ilsar & Bluff 2015), which also features in the AirSticks solo piece "*AirStorm"* which I will discuss next. *Storm* uses all of the MIDI information from the AirSticks and the *SoftStep* to move objects around the scrim and make them collide and bounce off each other, using a collision simulation. Andrew Bluff also created some light design for the piece, choosing moments in the show to light the band and to create silhouettes of the band onto the scrim.

The visuals were very much created for the music, not the other way around. Simple instructions from the band for changes in visuals were relayed, but at no point did the visual artists ask the band to change any of the music. As we performed and rehearsed *the Sticks "Visualised"* more and more, the visuals did start influencing the way we played the pieces. For example, in the new tune "*X-men*," not found on the album, the AirSticks needed to be

played in a different way to create a better silhouette and more pleasing visuals, which in turn changed the sound. Similarly, the piece "*Smoke*," named after the visuals created by Andrew Bluff, was in fact written with the visuals in mind, and each time it was played the piece got more and more sparse to accommodate for more satisfying visuals. This process would not occur if the band was set up in front of a traditional screen. Seeing the visuals in front of the band during the rehearsal process was essential for developing *the Sticks "Visualised"* show and making changes on the fly.

Again, even though this *Sticks "Visualised"* show is the current pinnacle of the AirSticks project and is currently undergoing further development, I feel it is beyond the scope of this thesis to explore the concept of audio and movement visualisation in greater detail. I will briefly describe another project with visual artist Andrew Bluff now, though I will focus more on the process of creating this work than on the visualisation system itself.

4.4.11 AirStorm (4/2015 -)

"AirStorm" is a series of improvisations and compositions inspired by working with visual artist Andrew Bluff. Andrew has developed a visualisation software, *Storm,* which he uses with various controllers including *LEAP Motion* and *Kinect*.

In "*AirStorm*," the movement data from the AirSticks is processed in real-time by Bluff's physics-based visualisation engine, *Storm*. Particles push around a virtual 3D world in response to the movements of the AirSticks and rigid body collision adds a sense of real-world authenticity and complexity. The system responds to hits and other movements of the AirSticks with a combination of different visual and physical effects. The real-time visualisations exemplify the movement and sonic complexity of the AirSticks performance, providing a visually stimulating and highly synesthetic element to the piece.

In March 2015, we started investigating ways that we could work together on a piece for the Creativity and Cognition Conference in Glasgow later that year. I used the same template mapping from *the Sticks* Dock residency and improvised some beats, sending Andrew the same MIDI values that I was sending to *Ableton Live*. We quickly put this completely improvised performance together for assessment by the conference panel.

"AirStorm Improvisation 1" by Alon Ilsar & Andrew Bluff (5/3/15)
https://youtu.be/UsPtnSEwYEY

The panel offered us a slot at the conference concert and we began to collaborate on an audio-visual 10 min piece. We also got asked to perform at the Centre of Art and Media (ZKM) in Karlsruhe, Germany, a few weeks later. Here is the footage of that performance.

"AirStorm Composition" by Alon Ilsar & Andrew Bluff (10/7/15)
https://vimeo.com/157508804

The process of making this piece, even without the visuals, was very different to any other project I worked on. Again, I wanted to create a more complete solo performance but without using loops. I wanted to play bass lines and melodies on top of the type of grooves I was playing around with in *the Sticks*. I decided to map a synth bass on my right hand and a lead synth on my left hand. Pitch would go higher away from my body, so on the right hand the pitch went up to my right, but on my left the pitch went up on my left. I decided to map the synths in this way to allow the safe zones to be the tonic and bottom note of each hand's mapping. I allocated a scale of my liking to both hands and began to improvise around this scale of just over an octave on each hand. This was one of the few melodic mappings I made, and being a percussionist that does not often deal with harmonic or melodic content I do not want to go into too much depth into the choices I made for this piece. I believe that an expert tuned percussion player or even piano player would want very different things to what I was trying to attain, and that the mapping possibilities of scales on a 3D playing space have not been greatly investigated during the AirSticks project, hence discussing this further is far beyond the scope of this thesis. However, there was one use of the AirSticks for exploring melodic content that I would like to outline here.

Throughout my experimentations with mapping the AirSticks, I have triggered sounds using two different systems. One is with the trigger point triggering system: a heavily theatrical and physical way of triggering sounds. Another is with the more discreet and efficient movement of pressing a button. The button I often choose to trigger melodic sounds with was the trigger button as it works similarly to a piano key and has a spring mechanism for some physical feedback. In "*AirStorm"* I used the trigger button to trigger and the control patterns of

arpeggiations which could be changed with other larger movements. This allowed me to 'play' and control impossible melodic phrases, with arpeggiations played at humanly impossible speeds. Throughout this project I looked for ways of using small discreet gestures to play humanly impossible musical phrases, but still have control over them with more transparent gestures. I will elaborate on this in the following chapters.

Another point of interest about this project was that I felt that for the first time in my solo AirSticks practice I had begun to truly compose on the instrument, in a more conventional 'electronic producer' manner. I started to see ways of mapping the AirSticks to allow the control over a program such as *Ableton Live* that I believe many composers would desire. Within my practice, however, I wasn't so excited about pursuing this kind of path. I will elaborate on this further in Chapter 6: Future Work.

4.4.12 The Sticks Covers Series (7/2015 – 1/2016)

The Sticks Covers series is a set of six covers shot and recorded in one take with no overdubs. This series was intended to showcase *the Sticks* as a live act and to help us learn from pulling apart tunes we liked and putting them back together. We originally worked on fifteen tracks, made demos of them all, and then focused on six during a second rehearsal period just before the filming/recording session. For all of these tracks, I used template mappings from *the Sticks* album, but all were heavily altered over the rehearsal period. For some I cut up samples from the original track, in a sense making live remixes, returning to the idea of a sound-first mapping approach. It was extremely useful to use these samples and learn how to play the main grooves of these tracks on the AirSticks. The finer details of this process will be discussed below.

"Crosshairs" (Dangerdoom) by the Sticks feat. Rapaport (19/1/16)
https://youtu.be/ISjOUIMv8mI

Crosshairs[58]

The goal on the AirSticks for this cover was to reinterpret the original acoustic drum sample used on the track, to emulate the groove but be able to take it away to a more electronic place later in the rearrangement. This original tune samples an acoustic drummer playing a straight 16th note hi-hat pattern. This 16th note hi-hat pattern was particularly hard to mimic on the AirSticks as one of the short comings of open-air controllers is their lack of haptic feedback, which makes it difficult to play with the same speed as electronic pads or acoustic drums. I ended up using the *Arp* triggered by holding the trigger button, and put it through a low-pass filter by rotating the wrist to the left to make it a little duller. With the volume mapped to the x-rotation, striking in time to this *Arp* pattern turns the volume up and down slightly, meaning

[58] To listen to the original visit https://youtu.be/YjIY0csyhrY

accented notes could be controlled with a similar gesture to a strike. Playing these accents on 8th notes was very satisfying to play around with and helped give the groove more of a human feel.

At the start of the piece, the band catches some 16th note hits. I again decided that it was wiser to use the *Arp* for this opening, though I had to make sure I practiced this part properly. Holding the trigger button created the 16th note pattern I needed for some of these hits, but I had to also time the flick of the joystick with the thumb to play a group of five 32nd notes with the rest of the band. Usually I simply use this flick for some colour in an improvised manner, but for this intro I had to execute it precisely on each take. I will discuss this use of this discreet gesture further in Chapter 5: Discussion.

Being locked into the *Arp* groove and hence a specific tempo allows some great ways to use delays on the kit and on the other instruments. I used this to throw delays on the rapper's voice in certain moments of this recording. The delay is controlled exponentially by two different movements – the delay is turned up when the left hand is rotated downwards on the x-axis, and is turned up further when the right hand is rotated up on the same axis. This creates the greatest intensity when the left hand is down (often after hitting a snare) and the right is up (in anticipation of playing a kick). In this way, the tension before certain bars can build and be released at the start of the next bar. Finding these kind of mapping elements that accentuate existing gestures was extremely satisfying.

For the rehearsal period just before the filming, we ended up changing the main sounds in this track a lot, actually using some original *Madlib* kit samples from other tracks, and layering them with some *808* sounds. Combining samples and synth drum sounds has become a standard when creating palettes for the AirSticks as I will explain later in a discussion on **sustain methods** and **ADSRs (**Attack/Decay/Sustain/Release envelopes).

One problem I encountered when working with the *Ultimate Morph Vacuum* template mapping on this cover was that some sounds needed to ring out without morphing. For example, hitting a crash and wanting it to ring out while moving back to the hi-hat was impossible. In the current setup the volume of the crash is assigned to the movement of the same hand as the hi-hat, and hence it fades out as I move away from the trigger point. Switching a function like this on and off with a button is a little difficult in the way I currently use *Ableton Live*, but I can imagine that this is the kind of function that would be assigned to a button in the future. Again, changing functions like this with discreet gestures can help with the controllability and flexibility of the instrument but reduce transparency for the audience.

"Indian Deli" (Madlib) by the Sticks (19/1/16)
https://youtu.be/sG1ebL1G33s

***Indian Deli*[59]**

This was the first groove in which I only used cut up samples from the original track, which itself is made up of samples from old Bollywood films. I used eight samples for this track, four for each of the two chords. Using chunks like this was really interesting. It becomes more of a live remixing exercise. Phasing became a problem with the samples from each hand overlapping and being panned differently, but I fixed this by losing the panning and really focusing on practicing pulling up each hand before the other struck.

This was essentially an exercise in sounding the same as the track itself. Adding the filter delays on the right hand did help it move away a little but it was really about showing that we could embody this track, particularly with the others learning to play the melodic samples on traditional instruments.

It was nice to stand for this one: freed my legs up to move more naturally and meant that the transparency of the hand gestures was not blurred by triggers on the feet.

[59] To see track listing for whole album *Beat Konducta in India* album visit https://www.stonesthrow.com/store/album/madlib/beat-konducta-vol-3-4-beat-konducta-in-india

"Wishes" (Beach House) by the Sticks feat. Elana Stone (19/1/16)
https://youtu.be/szQ_xabhq_k

Wishes[60]

The original of this song by Beach House begins with drums that sound similar to some of my previous work on the AirSticks, particularly *Casio* sounds triggered by the *Arp*. Halfway through the original track, an acoustic kit is laid over this beat, so it was nice to add the more transparent large gestures on top of the *Arp*. With the way I have mapped the *Arp* changing with xyz position and rotation, playing larger gestures also affects the *Arp* sounds, giving much life and movement to these generated patterns.

Since I was largely using a mapping I was very familiar with for this cover, we had the freedom to quickly arrange this tune as if we were an acoustic band as no samples needed to be uploaded or loops prerecorded. We just sat together and listened to the original, made charts and made suggestions for sounds and arrangements. This to me is one of the real strengths of the AirSticks and one of my favourite ways of collaborating within an ensemble.

We made subtle use of effects on the bass to lift different elements out during the song, and threw delays on the vocalist in a similar fashion to "*Crosshairs*." This is one tune where it would be good to play to a click track so that the *Arp* is always in time even when it gets swallowed up by the acoustic kit samples later in the song, but instead I kept the *Arp* going throughout so we didn't go out of time with it. This is a shortfall of *Ableton Live* that I have investigated thoroughly but cannot get around. *Ableton Live's* clock, even when it's not running, keeps the *Arp* playing in sync, meaning I cannot retrigger it precisely when I want to, to move with the timing of the band. It does not do this for the *Chopper* for example, and hence they would go out of sync with each other, though still at the same tempo. I am still exploring

[60] To listen to the original visit https://youtu.be/OS6duOoxctw

ways of fixing this in the future software so that the trigger button can be used to reset the start of a pattern.

Overall, this was really good use of *the Sticks* album mapping, and there wasn't much tweaking to do to the mapping. This allowed me to really focus on arranging and performing the piece.

"She Moves She" (Four Tet) by the Sticks (19/1/16)
https://youtu.be/UGjKUockJJ8

She Moves She[61]

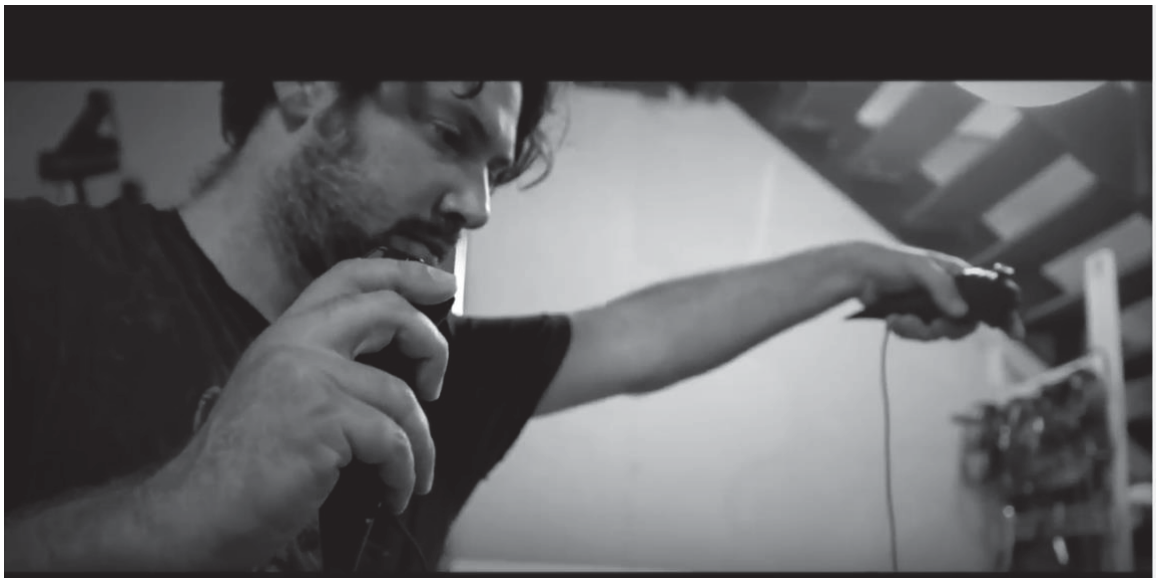
This was another track cut up from the original, including some short guitar stabs and a long verse sample, placed out wide and up high in the playing space, respectively. With this track, I wanted the option to morph in and out of these longer samples unlike with the crash discussed in "*Crosshairs*." Triggering these samples at the same time and then being able to cross-fade between them became a tool I used more often when taking more of a 'sound design' role.

It was really satisfying to use very well produced sounds from the original track. It makes the instrument 'feel' so much better. This is quite an abstract concept but shows how important aural feedback can be when there is no haptic or tactile feedback with an instrument. At first, I emulated the beat exactly but we quickly realised that doing this made it sound too much like the original. Using the samples but playing a different feel seemed more meaningful, and playing the original groove later in the arrangement was more satisfying compositionally. Again, this was very much a remix, though the reharmonising arranged by the other band members takes it away from conventional remixing. I feel that this is a great example of how the AirSticks can push other musicians in new directions with their writing and playing as they

[61] To listen to the original visit https://youtu.be/CWTAOwgTbu4

find themselves in very different musical situations to what they are used to in conventional acoustic bands, or playing with more standard electronic setups. It was also rewarding to have some simple melodic content to play on the AirSticks in this track, and I felt it freed up the others a little more.

I decided to not use my feet in this performance which freed me to stand up again, gaining further transparency and increasing my reach. Playing samples like these that are made up of short rhythmic cells is really hard to get super tight, but maybe that is part of the charm of the AirSticks. I avoided using too many button presses which is nice, just bringing in the *Chopper* a little here and there with the trigger button, and adding delay right at the end by pushing the thumb joystick forwards. Avoiding these discreet movements is most ideal for me in attaining higher transparency to the audience, and when working on shorter pieces with little room for improvising, it makes most sense for me to keep the mapping as simple as possible.



"Building Steam" (DJ Shadow)/ "Aquarius" (Boards of Canada) by the Sticks (19/1/16)
https://youtu.be/ADVomKdKbpY

Building Stream[62]/ Aquarius[63]

This track began with me cutting up the *DJ Shadow* drum break samples, but from the original that he himself had sampled. I also found the original interview that the narration is sampled from, and used it as a starting point of this mash up / cover / remix. Since *DJ Shadow* made this track all on an *MPC*, the cut-up drums seem very relevant. Finding other samples from the interview created a development to the narrative, with the voice samples being mapped around the kit and pitched up and down like a record. Again, some samples seemed to need to ring out after the hand had moved away from their trigger point, so I had to compromise some of my playing to make this happen. Changing the pitch of the drum samples did not work for us

[62] To listen to the original visit https://youtu.be/dcxsheROd3E
[63] To listen to the original visit https://youtu.be/St-mEIhvKOI

aesthetically as the ride cymbal rings throughout all the drum samples and does not sound good getting pitched up and down constantly.

We used the vocal samples to narrate the concepts of improvisation and practicing on the drums, particularly of developing speed. The middle of this arrangement includes a sample of a drummer talking about how his students should relax and play slowly and that the speed will follow naturally, a valuable lesson in learning any instrument. As the left hand of the AirSticks reaches up and to the left to play this sample, fading it up as other samples fade out and controlling its pitch on the z-rotation, the right-hand triggers a relaxed pulse with the trigger button, which slowly speeds up with the thumb movement to an impossible speed as the sample comes to an end.

We decided that the *DJ Shadow* track was not that exciting musically on its own, so we mashed it up with a similar sounding bass line from *Boards of Canada's "Aquarius*," which itself is sampled from the musical of the same name. The keys player found a really similar synth sound to the original and we began to restructure the piece with the *DJ Shadow* tune and the three sections of "*Aquarius*." The voice samples started making even more sense as pitching them down and using them as short percussive syllables is something *Boards of Canada* also do a lot. We combined the *DJ Shadow* vocal samples with ones from the *Boards of Canada* track, which were originally sampled from the kids' TV show, *Sesame Street*. *Boards of Canada* use a very nostalgic reverse effect on their drums that emerged from using the *Arp* on 1/4 notes as the hand moved from one sound to another with the reverb frozen, creating a swishing sound. A circular motion was made with the right hand as it was getting filtered to add further movement to the sound.

The *Arp* was used in a new way in this track. Instead of the *Arp* being completely different sounds to the kit triggered by the larger gestures, holding the triggering button repeated the same sound triggered by striking through the air. This allowed me to morph from one sound to another while the *Arp* repeated the trigger sound at a rate controlled by the thumb. This *Arp* mapping currently only allows the repetition and change of pitch of the one sound. Again, the problem with the retriggering system on the *Arp* in *Ableton Live* made this quite difficult to play without a click track. I also mapped the *Arp* in a way that holding the trigger tighter turned the volume of the sample up which allowed for further dynamics. Using the trigger button for volume is quite satisfying as feels like playing a one-note keyboard synth that is controlled through movement.

We did decide to play this along to a click track to sync the *Arps*, *Chopper* and my playing more precisely. We also added snares to the *Boards of Canada* section later in the piece to give the track some lift up after the drop-down section. Lastly, we set up a choking system for this track so that the left hand cuts the sound of the right and vice versa. This eliminated the phasing issue and allowed us to keep the panning of samples.

This ended up being a great showcase of the AirSticks, with a lot of nice camera work focused in on some of the more subtle uses of the trigger buttons and thumb joysticks.

"Anthem for the Earnest" (The Bad Plus) by the Sticks (19/1/16)
https://youtu.be/84CFdukpr-U

Anthem For The Earnest[64]

This began as an exercise in learning a relatively complicated modern jazz tune, but slowly turned into something very exciting. We wanted to make *The Bad Plus* sound like *Aphex Twin*, as they had indeed famously covered *Aphex Twin* themselves.[65] The repetitive rhythmic 1/8 note drive of the original on piano, bass and hi-hat was mirrored with a *Chopper* effect from the AirSticks which was linked to the *Arp* to create an *Aphex Twin* style groove. All the sound of the other band members was processed through the AirSticks in this track. By pressing the trigger button I cut their long notes into quavers. I could change this rate with the thumb joysticks. Their sound could be filtered and put through reverbs and delays without hearing the dry signal. The momentum of the piece comes from the slow development of more fast chopping of the instruments with the occasional letting through of the sound by releasing the trigger button.

There were tricky timing things to learn with the trigger button in this one, but it was good to start playing defined prewritten rhythms with the fingers like at the beginning of "*Crosshairs*."

Like in "*Wishes*," this again was a very natural use of *the Sticks* main mapping. I did turn the snare off from going into the *Chopper* though so it could cut through, a system I will use more in the future I'm sure. I also put a slow phaser on the snare so that it would sound slightly different each time I played it. This gave the snare a lot more life and made me consider how to use and control **LFOs (Low Frequency Oscillators)** further in the future.

[64] To listen to the original visit https://youtu.be/ApNzukkcY14
[65] For *the Bad Plus'* cover of *Aphex Twin's "Flim"* visit https://youtu.be/EYimjHuU99c

In summary, the arranging, remixing and covering of these six pieces on the AirSticks (in the role as drummer) with two expert musicians on their respective instruments, needed a very different approach to *the Sticks* improvised led projects such as *the Sticks* Dock residency. Taking a sound-first approach, having a strong knowledge of the original songs and then using the AirSticks to reinterpret each song, meant I needed to restrict the sound palette considerably. Mapping decisions needed to be made that would limit the exploration on the instrument, keeping most of the exploration within the mapping process. Having played the AirSticks for over 3 years by this point helped me gain a strong understanding of what mappings would work for each piece. Also, because we were to film all these pieces, special consideration needed to be given to how the performance looked, another point of difference to *the Sticks Debut Album*, where the focus was completely on the recorded sound.

4.4.13 Tuka on Like a Version (11/2015)

In late 2015 rapper *Tuka* approached me to perform AirSticks on two tracks that he was about to do live on radio.

"Big Jet Plane" by Tuka feat. Alon Ilsar (5/11/15)
https://youtu.be/7udwea5-psY

Big Jet Plane

Tuka sent me the produced track to listen to and said that this was how he wanted it to sound. My initial instinct was to mime the whole thing, and not just the percussion parts but also some synth parts too. If the track needed to sound a certain way, and no one knew what the AirSticks could do, why not just mime the ideal way that I would like to move to the perfect recording? Bands often mime live performances on TV, and all certainly mime on music videos.

Listening again to the song I realised that it would actually be easier for me to play some of the parts then mime all of it. The producer did want me to add an element of improvisation and subtle changes to the timing and timbre of the track to showcase the instrument a little. I decided that I should figure out how to play the track on AirSticks, as one-shot strikes and some loops.

I received the files as stems and put all of the 'backing tracks' and drums on separate channels. I decided to play as much of the drum sounds live as possible, and keep any melodic sounds in the backing track to maintain the palette of the AirSticks within a percussion world. I wanted to take a similar approach as an *MPC* player would for a hip hop tune, and indeed in the radio interview before the performance *Tuka* did compare the AirSticks to the *MPC*.

The song was basically divided into two sections; a very open kick/snare section, and another with a dense looped drum break sample. I decided to stand for the performance, and

'dance' through the opening kick/snare section, occasionally adding reverb or a filter or a delay or some more characteristic AirSticks sounds not from the produced arrangement. Being synched to the rest of the track meant the delays and *Arps* were super easy to trigger and I could not trigger them out of time with the track. *Tuka* seemed to like the slight variations I was giving this kick/snare pattern, and I focused on adding these nuisances in between vocal phrases. I mapped a hi-hat loop to the front of the right hand's space and faded it in as instructed. I also layered the snare with another snare closer to the front of the left hand's space.

The second section of the song started with a heavily low-pass filtered drum break slowly being filtered in, with a snare pattern played on top of it, and a crash bringing it in. I decided to put this drum break on a separate part of the backing track so I could manipulate it separately to the rest of the backing track. I did want to 'play' it more on the AirSticks, but realised that retriggering the loop at the start of the bar would be too difficult on the AirSticks. It would look kind of boring and would not sound as precise as the producer would like without serious quantisation. I decided it would be better to mime the way I would like to play it, and add a beat repeater effect to cut up the sample with the trigger button on the right controller, changing parameters of this effect by moving forward and left/right. I also mimed the crash cymbals so that they would be consistent in volume like in the produced arrangement. I think being a drummer helps to know how to mime meaningfully to these produced beats. I realise that there is a lot of work with quantising sounds that could be done in the future to make the sound more consistent and hence avoid miming but this is for a future project.

I developed the choreography of the piece in a way that if the camera was on me the whole time the workings of the instrument would reveal themselves. But since the camera only cut to me a few times, this narrative was lost.

The performance was extremely successful. The video has been viewed over a million times and the piece reached number 81 on Triple J's Hottest 100,[66] Australia's biggest countdown of the year's most popular songs voted by over 2 million listeners. No one has commented about me miming in any part of the song, most probably because I am not miming at the start of the piece and so the instrument's transparency is 'sold' early on. But also because no one knows what the instrument is capable of. I have the space to play with the audience's perception of what is possible. Many of the comments on the YouTube page do mention the AirSticks in a positive light, though I think these should be taken with a grain of salt.

It was never my intention to do any type of miming with the AirSticks, but as will be outlined in Chapter 5: Discussion, there is a blurry line between playing and miming when dealing with a new open-air instrument such as this one.

[66] For the complete list of the countdown in 2015 visit http://www.abc.net.au/triplej/hottest100/archive/archive.htm?year=2015&alltime=0

My Star

This original song of *Tuka's* was to be an 'acoustic' performance with no backing track. *Tuka* was the one who described this performance as 'acoustic' which I found interesting. He couldn't find the word to describe what the AirSticks were doing. They fell in between the usual acoustic percussion and electronic backing track in mainstream hip hop.

Again, I chose to stand up for this piece. I made a simple kit using only *808* sounds and some sound synthesis. It was nice to not use any delays or *Arps* or loops in this, really play it like a kit. *Tuka* did suggest that I use brushes originally, so I wanted to do my 3D brushes thing with the white noise filters.

This track has been viewed by over a quarter of a million people and was well documented so I felt it was worth including in this thesis. The major revelation for me from this performance was how satisfying it was to make a super simple mapping like this. I have recently pursued this idea of simple drum synth mappings further in my creative practice in an attempt to compose, improvise and perform minimal electronic music inspired by morphing rhythms and an exploration of FM synthesis.

"My Star" by Tuka feat. Alon Ilsar (5/11/15)

https://youtu.be/e3OE-q6OC8c?t=2m32s

4.4.14 Creative Tech Week Talk (4/2016)

In May 2016, I was asked to do a talk at an event called Creative Tech Week in New York City. I have included this here as a case study even though it's a solo performance because it demonstrates some key concepts of this thesis. The organisers wanted for me to talk about the AirSticks for 15 minutes. I decided that instead of simply talking about the AirSticks, I would demonstrate the way they worked at the same time as talking, manipulating my voice and triggering other samples, turning the talk into more of a performance than pure talk/demo. My narrative was based on many of the concepts I will discuss in this thesis, but I do believe that it is worth watching the link provided to get a more visual and succinct form of this narrative. One element I want to bring out before I move to the next chapter is that of **sample length**.

Creative Tech Week Talk (7/5/16)
https://youtu.be/BHD0VEsxbJU?t=36s

In the talk, I use the *Aphex Twin* track "*Vordhosbn*" as an example of electronic music that really inspired me in my early 20s. Before fading in and discussing this track, I speak about another inspiration from those formative years – jazz drummer Elvin Jones. I begin the talk by playing two one-shot samples on the AirSticks, one kick and one snare sample, from the very start of Jones' solo from John Coltrane's piece "*Vigil*." I play the same simple rhythmic theme as he does in his solo, and then let him respond by triggering the original sampled phrase with the discreet movement of the bumper button, as if his ghost were there responding to me. I eventually let his sample play out and turn into the rest of his solo. I ask the audience what they visualise when hearing a drum solo and argue that listeners may visualise a drummer and/or a drum kit, as we all know what drums look like and how they work. I continue to speak over the track:

'I can feel the energy in that room. Makes me want to air drum along. I wish I could go back in time and be there for it… for that moment when Coltrane joins in and they converse as the spirit of their improvisation lives on 50 years later.'

I then fade the improvisation out as the reverb consumes the track like a distant memory. I go on, while playing some acoustic drum samples on the AirSticks to talk about the limitations of the drums, and explain that my exploration of the drums led me to explore another universe of sounds, that of electronic music. As I fade in the *Aphex Twin* I begin to say:

'This is Aphex Twin. A true inspiration for me. I would play along to this record too, mimicking these beats on the drums. To me this has such an energy coming out of the speakers. It also makes me want to air drum along… though how do we air drum to this? What musician or instrument can we visualise when we hear this music, this music that had never taken a physical form. That was never played in a moment in time. These sounds now exist inside a computer. So can we bring the physicality of the drum kit to these sounds? … We all know that watching a performance of electronic music can be even less entertaining than watching someone speak over electronic music. At least in this speech you can watch my lips moving, and feel my nerves as I struggle to say the right words or press the right button.'

I then press a button that plays a prerecorded sample of my voice continuing to talk about electronic music. I demonstrate that I have more control over the *Aphex Twin* track than just volume. I can filter the track, pan it left and right, put it through changing delays and reverbs as I twist and turn my arms. I ask whether having control over these parameters makes the performance more entertaining, or interesting, or transparent. Where is the line between the AirSticks being a simple on/off controller and an expressive instrument?

I argue that the shorter the samples triggered, the more transparent the instrument and hence the more the performer can embody the instrument. I demonstrate this by playing the first 16 bars of the *Aphex Twin* track across eight samples. I then argue that once these samples are mapped in this way, the performer is not restricted to playing the original track and hence can more freely improvise with the samples. I play shorter samples still from the original track, arguing that the sound and movement is more related the shorter each sample is. Then I continue to improvise with these shorter samples, playing a beat that is almost completely unrelated to the original. I believe this investigation into transparency and embodiment using sample length can really help the instrument designer decide whether to place more importance on sound or on movement. I will investigate this choice further in the next chapter.

4.4.15CF1 (6/2016)

"CF1" is a piece I wrote and coproduced with electronic producer Greg Seiler aka *Comatone* in 2005. We only performed this piece live on a few occasions, with Greg playing the 'backing track' and me playing drums on top of it.

"CF1" by Alon Ilsar, Greg Seiler and Hannah Cohen (11/6/15)
https://youtu.be/puPGY3-Jw0I

The idea with this new solo performance of "*CF1"* was to interpret it for an AirSticks performance and to work with a choreographer to bring it to life. I played the full track on my computer and mimed over it a few times, imagining ways that I could trigger the sounds with the AirSticks. Once I was happy with the movements I was making, and believed it to be possible to map on the AirSticks through *Ableton Live*, I began to cut up the piece into playable samples. I then broke the piece down into sections to focus on how I wanted to trigger and manipulate each sample in these sections.

I decided to bring in the drone that starts the piece by pressing on the trigger button and bringing my left hand towards me from above. This was easy to map in *Ableton Live* as I simply mapped the volume of this drone to the y position, but it was also really pleasing to explore this way of moving. I could then also filter this drone with the right hand. The choreographer and I discovered that drawing out imaginary drums with this right-hand filter and then triggering drum samples by striking through these imaginary circles would be a great way to 'set up' the virtual space for the audience. The 'drum solo' that features in the original "*CF1"* could then be played and put through delays and other effects before sucking all the sound out and leaving a piano part hanging over into the next section.

I decided to trigger this piano part with the bumper button on the right hand. When my

hand was closer to the hub it would trigger on high-pitched piano phrase, and if my hand was closer to my body it would trigger a lower pitched piano phrase. Even though the sound could be made by just pressing the bumper button, I decided to add more movement with the right hand, following the rising and falling of the pitch of the phrase with movement to the left and right, like plucking the strings of an upright piano.

I was then faced with my ongoing problem in solo performances of how to trigger loops. I decided to trigger the bass line loop with the left bumper button and map the volume of the loop to the x-rotation of that hand. When the choreographer saw that I was fading up the sample in this way, she suggested that I visualise this gesture as pouring water out in front of me. She asked me to watch the imaginary water come out of the controller, and to then break this stream with the right hand as I triggered the piano sample. This was an extremely satisfying moment, and was even commented upon by an audience member after the performance of the piece.

Another revelation I had from working through "*CF1"* in this way was the idea of playing a part on one hand and then throwing the sound to the other hand for looping and filtering. Also, the metaphor of stirring a big vat of broth came out of this performance, and was mentioned by other collaborators later on in another setting. This idea of using the AirSticks like a **magician** or illusionist, triggering some samples but also miming others with more figurative gestures will be elaborated on in the next chapter.

One disappointment with this project was that I felt that I had fallen into old habits of mapping the AirSticks. My main reason of getting a choreographer in for this project was to collaborate with her on bringing new movements into the AirSticks mapping. But because I brought in such a complete performance before she even came in to work with me, her role became more to fine tune the movements I had already mapped. We have since worked on a new project, *Voyager,*[67] where her involvement occurred much earlier in the process. Since she knew more about the workings of the AirSticks by then, she could bring in more appropriate choreography ideas for the AirSticks mapping, before the mapping was done.

[67] See **Appendix D**

4.4.16 Daft Punk (7/2016)

Please watch this video before reading on.

"Da Funk" (Daft Punk) AirSticks by Alon Ilsar (11/7/16)
https://youtu.be/8fAmdGLrgvA

Did you notice anything?

The *Razer Hydras* are not even plugged into the hub in this video, nor are they plugged into the computer. I am completely miming in this video.

Since the beginning of the AirSticks project I would listen to electronic music, literally close my eyes and imagine ways of playing the music on the instrument I was about to create. I decided in mid-2016 that it was time to find a simple popular instrumental electronic music piece and film myself miming the way I would want to play the track on the AirSticks.

I picked the *Daft Punk* song, "*Da Funk*." With this project happening so late in this research project, I had already established a language of gestures on the AirSticks. The process began with listening to the track and miming along to it, noting which gestures made the most sense to me in representing the sound. This helped me in quickly identifying ways of 'playing' (or miming) the music through intense listening and visualisation of the playing space.

I grouped movements into four categories:

1. triggering a sound
2. looping a phrase
3. bringing loops in and out
4. manipulating the sound

I then 'mapped' out where all the sounds would be placed in the playing space starting with snare on my left, and hi-hat and kick on my right. A gesture of striking a space above the head was used to communicate to the audience that a phrase is looped. To stop a loop, the hand was put into that same area of the playing space and the wrist was flicked upwards. This drum loop was then put through a high-pass filter, by the use of a gesture of turning a knob to counter-clockwise. Next, the main melody of the song was played with pitch mapped from left to right like a piano or vibraphone. Special attention was given to note length and a low-pass filter on the end of the sound being controlled by the rotation of the wrist. Further parts were added on top of the loops, and then the hands were used to add reverb and delay to the track, by lifting them high and away from my body.

Though completely mimed, I feel this performance looks very much like I am playing the instrument. Music videos are always lip synched, and all the instruments are mimed, often quite badly. In fact, there are movies such as *The Conversation* that are notorious for bad miming of instruments on the screen.[68] This miming may be more difficult to pull off on other acoustic instruments or electronic pads, as the strike needs to be more precisely timed, but on the AirSticks it is easy to 'sell' that I am in fact playing the samples if you believe that this technology can exist. Also, performing with the AirSticks actually feels exactly the same as miming, as there is no haptic feedback and only aural feedback either way.

The main reason for this exercise, however, was to help decide which movement I wanted to make for each sound. This exercise freed me of the mapping processes that I was getting used to with the AirSticks, and helped me invent new ways to more instinctively control the sound. I am now working on creating this mapping in *Ableton Live* to play for real and allow a form of live remixing and improvisation with the themes of the track.

I will discuss this extreme of sound-first mapping further in the next chapter. It is worth noting that a well-mimed performance in theory does not change the experience whatsoever for the audience, but it completely changes the experience for the performer. In the miming situation, the performer has no control over the sound at all, and very little space to improvise with her/his movements. But the AirSticks player knows that s/he is in control of both the sound and the movement of a performance. This is a concept I will also elaborate on further in the next chapter.

[68] To watch the scene referred to here, visit https://youtu.be/o8-i7lA5gic?t=40s

4.5 Conclusion

Throughout each artistic research project, I began with an idea of either what I wanted each performance to look like or what I wanted it to sound like. I explored various palettes and effects – room feedback, acoustic instruments, the voice, the elements, drum sample banks and synths, looping, reverbs, delays, distortion and bit reduction. I designed ways of controlling these through movement.

I also explored movement metaphors – drumming, strumming, conducting, cueing, knob turning, fader pushing, scratching, splashing, slashing, rope pulling, pouring, squeezing and grabbing. I designed ways of turning these into sounds. I also grappled with notions of miming and illusion, of how to imagine the playing space, and of when to involve more discreet movements into mappings.

Through reflecting on these projects, a number of different approaches to tackling the **mapping problem** and overcoming **creative paralysis** emerged. In the next section I will discuss and classify all these different approaches that I discovered through these projects.

Chapter 5:

Discussion

5.1 Introduction

In this section I will focus on the fourth research question as outlined earlier – (Q4) *what are some effective ways of tackling the mapping problem?* I will explore several approaches to tackling the **mapping problem** and overcoming **creative paralysis**, elaborating on concepts that emerged from the pivotal projects that involved the AirSticks over the last four years. Several concepts from these projects will be brought out for closer investigation and discussion. Some of the concepts outlined in this chapter will take the form of reflections on decisions I have made in the mapping of the AirSticks, and others will take the form of a wish list of things I found myself wanting to do with the AirSticks but was constrained by the hardware and software. This will lead into Chapter 6: Future Work and the investigation of new hardware and software ideas.

During this chapter I want to let the reader's imagination be freed of any hardware limitation, hence I will defer one of the research questions – (Q2) *what are some effective ways to utilise the latest in motion capture technology?* – to a discussion in the next chapter on the possibilities of new hardware for the AirSticks. I also feel that this particular research question was addressed more closely earlier in the project and hence earlier in this thesis, specifically in the sections, Project History and Current Hardware and Software.

DMI designers are 'bounded only by imagination and hardware capabilities' (Mullin 2010, p.24). It is inevitable that hardware for future instruments will keep improving and be more accessible to the wider community. I myself am not a hardware engineer, nor am I a computer programmer. My specialty lies in imagining ways that we can use the body to make music, particularly that part of music we call rhythm. Through my experience as a drummer I can therefore focus on another research question – (Q1) w*hat are some effective ways to utilise the existing motor skills of expert drummers in designing the AirSticks?* Over the last four years I have been both inspired and frustrated by the technology I have had at my disposal and have consistently returned to acoustic percussion with new energy and gusto. I will address this research question throughout this chapter particularly in a section on the use of mapping by metaphor. I will also elaborate further on my relationship with acoustic percussion in the Future Projects section.

During this section I want to explore the ideas I have had and conclusions I have come to throughout this project and reintroduce some thoughts and ideas of other instrument designers.

In attempting to tackle the mapping problem and addressing Q4, I will begin with an investigation of the concepts of mapping that emerge when sound is prioritised ahead of movement, starting with a discussion of what I have identified in certain case studies as **sound-first mapping**. What considerations need to be taken when leading with a sound? What do we learn from watching musicians **miming** on their instruments, or kids playing air drums or air guitar, or dance choreography to pre-existing music? What advancements in software design would we need to better facilitate sound-first mapping? I will try to break down the idea of

what sound is further and further, from a whole organised composition, to a part of a piece, to a phrase or chunk, and finally the one-shot sample, in the hope of simplifying this immense mapping task.

I will then investigate the concepts of mapping that emerge when movement is prioritised ahead of sound, starting with the metaphor that this whole project began with, that of drumming, building from the initial question of what sounds should be made from a strike through the air, and how should these sounds be manipulated through other gestures. I am calling this approach **movement-first mapping** and within it I will also discuss the notions of **mapping by metaphor** and the imaginary **playing space**.

I will also discuss the use of sound **synthesis** in new instrument design, particularly **FM** and **granular synthesis**, and how open-air controllers lend themselves to **ADSRs** and **LFOs**. I will follow this with a discussion on the use of basic **effects** such as panning, filtering, reverb and delay, which will lead to a short discussion on **looping** and the use of **discreet** movements to control computer processes that can perform tasks well beyond what is physically and humanly possible to play.

I will then break down the idea of **composition** and **improvisation** in another way, by isolating genres of music that I found worked best on the AirSticks, that played to the strengths of what movements could be made with the instrument. I am calling this **genre-specific mapping**.

I will end this section by discussing the **collaborative** nature of electro-acoustic improvised music which will lead into a discussion on improvisation and **mapping for ensemble playing**, more specifically addressing the last research question – (Q3) *what ways are there to facilitate more satisfying collaborations between artists across different artforms without technology hindering the creative process?*

But before I go into these approaches to tackling the mapping problem in detail, I would like to make a comparison between acoustic and electronic instruments that from my research has not been made by other scholars.

Many DMI designers study acoustic instruments to help in their decision-making process and to overcome their creative choice paralysis.

'By studying effective acoustic instruments, choosing intuitive but complex gesture-sound mappings that take advantage of established instrumental skills, designing intelligent characterizations of performance gestures, and promoting long-term dedicated practice on a new interface, computer music instrument designers can enhance the expressive quality of computer music performance.' (Dobrian & Koppelman 2006, p.1)

However, I want to make a different comparison that I have not come across before. Here I want to compare the *setting up* of an acoustic instrument with the *mapping* of a DMI.

5.2 Setting Up Vs Mapping

Most acoustic musicians have different choices they must make when packing their instrument into the car. Guitarists may have several types of guitars and strings to choose from. Horn players have different key register saxophones and reeds, brass players different mouth-pieces and mutes. Percussionists in particular own several different drums and cymbals, sticks, brushes, mallets, and various bits of percussion, and also must decide where all these will be placed. Each of these decisions will change the options they have further down the line.

For example, if a drummer is offered to play a jazz gig in a small room on the drum kit s/he would most likely bring a small three or four-piece kit, of smaller drums, a ride cymbal or two, thin sticks, mallets and brushes. S/he would set all the drums as close to each other as possible to allow the most **efficient** playing. If s/he knew the band was going to play some latin jazz or bossa novas s/he may also bring a cowbell, woodblock and shakers. While setting up the kit s/he may tune up the drums a little to accommodate for the acoustics of the room.

If this drummer was offered to play with a metal band in a studio, s/he would most likely bring a bigger kit, and more cymbals, maybe a china cymbal, and thicker sticks. S/he would pack a double kick pedal, some Gaffer tape and tune the kit accordingly. If the session was being filmed s/he may even set up the cymbals a little higher than usual to bring more theatricality to her/his playing. The sound engineer would mic the kit up in a certain way that works best for the music.

These examples seem simple and obvious when dealing with the drum kit, but they are not often considered in the design of a DMI. The mapping used in a performance on the AirSticks, or any DMI, dramatically affects the music played. 'Any mapping control structure for a given digital instrument is determined by the musical context in which it is used' (Van Nort, Wanderley & Depalle 2014, p.6). At the start of each musical situation a mapping must be chosen, just like a drum kit is packed into the car. I have been calling this type of mapping a **template mapping,** first defined at the end of Chapter 2 as part of my refined design criteria. As presented in the case studies, I had created several template mappings for different types of musical situations that I would keep building on in new projects. The objective with the AirSticks has been to make several template mappings and make the changing of these mappings as simple and as physical as the setting up and tuning of a kit, using the controllers in an 'edit mode' to move the location of sounds and adjust the sounds and effects themselves. This will be discussed further in Chapter 6: Future Work.

This approach of designing several template mappings fits in line with Perry Cook's recommendation for DMI designers to 'make a piece, not an instrument or controller' (Cook 2001, p.1). He goes on to stress the difficulty in designing a 'super instrument' suitable for many musical situations, however I do see the AirSticks as this overarching instrument which can be mapped (or set up) in several ways. Also, the use of the word 'piece' by Cook implies a composition, as opposed to a tool or vehicle for **improvisation**. As stated throughout this thesis, part of the design criteria of the AirSticks was to allow the improvisation, composition

and performance of electronic music. In choosing a template mapping, I had to decide which of these I intended to do, along with several other factors which I will outline now.

5.2.1 Improvisation, Composition & Performance

A major influence on the choice of template mapping was whether the collaborators and I intended to purely improvise, compose through improvisations and rehearsals, or perform a composition. The AirSticks, like any instrument, can be used:

- as a tool for improvisation;
- as a tool for composition; and,
- to help perform pre-composed music.

To simplify these concepts, I will refer to them as improvising, composing and performing, respectively. Of course there is a blurry line between these three categories. On one extreme there is the performance of a predetermined fixed composition. The instrument is used purely to perform the task of bringing the composer's music to life. This may be through reading a score, or, as the case in many electronic music performances, pressing play. This method of pressing play is extremely successful at presenting the exact predetermined fixed composition as intended to be heard by the composer, without room for any human error, but can lead to a very boring performance. This will be explored further shortly.

On the other extreme there is completely free improvisation, with no preference at all for any sound that is made. Of course the choice of instrument will dictate largely the possibilities of the improvisation, and it could be said that the choice of instrument is a compositional decision, putting a restriction on the performer edges the performance towards being a composition on the improvisation/composition spectrum. This is where the line between composition and improvisation gets particularly blurry. Human 'error' or expression can be seen as improvisation within a composition, whereas restrictions on an improviser can be seen as compositional ideas. What blurs the line further between these approaches to making music is that once an improvisation is recorded and played back it can then be considered a composition, one that can be transcribed and re-performed. Moreover, many composers use their improvisations as inspirations for compositions, rehearsing an initial idea or improvisation until they can re-perform it as a composition at will. This was the approach taken in such pieces as "*Air Vacuum"* and "*AirStorm*."

In returning to the analogy between setting up a drum kit and mapping the AirSticks, how does the choice to improvise, compose or perform change the setup or mapping, and what new possibilities open up when using electronic instruments in these three situations?

5.2.2 Efficiency vs Theatricality

One concept I had to consider for each project's template mapping, across improvising, composing and performing, was whether to prioritise sound or movement. I am calling this dichotomy **efficiency** vs **theatricality** and I briefly touched on it above in the jazz vs metal performance on a drum kit example.

- **Efficiency** refers to prioritising setting up or mapping in a way that makes it easier to execute the desired sound, for example in a recording studio.
- **Theatricality** refers to prioritising setting up or mapping in a way that makes it easier to execute the desired movement, for example in a dance show.

It could be argued that dancing is not a musical situation in that the dancer does not have any control over the sound, but I feel it is worth setting up this extreme to better understand the problems faced in mapping electronic instruments in situations where the music is pre-composed and the intention of the performance is to sound as much like the original recording as possible. This concept was brought out in my final case study on performing the *Daft Punk* cover and I will elaborate on it shortly.

5.2.3 Predictable vs Unpredictable

Another spectrum that is more useful within the world of improvised music is what I am calling the **predictable** versus the **unpredictable**. The concept of the **unpredictable** is 'exploited through the amount of control exercised over the instrument, from complete - producing exactly what the player dictates - to none at all - letting the instrument have its say' (Bailey 1993, p.100). In the setting up or mapping designed for performing a predetermined fixed composition, an instrument must be perfectly predictable, whereas a setup or mapping for a completely free improvisation may involve a more unpredictable output from the instrument as inspiration for further improvisation.

- A **predictable** setup or mapping prioritises the musician being able to perform a predetermined composition or communicate the sound heard in their head through the instrument.
- An **unpredictable** setup or mapping prioritises the musician being able to further explore an instrument through physical movement.

An unpredictable setup or mapping attempts to help the advanced performer break physical habits. I use the word advanced here because a beginner on any instrument has no habits to break and hence is constantly exploring the instrument through the learning process. Many advanced performers want to be challenged into discovering new sounds through movement, as opposed to trying to attain a sound that is in their head. With an acoustic instrument this exploration has a strong grounding in the physics of sound as the performer has some idea of what sound will be generated through a particular physical movement. With DMIs, since the input and output is decoupled and removed from the natural relationship between movement and sound, mappings can be created that invite the performer to explore a **playing space** in ways never possible before. For example, the sonic output of the instrument for a specific

gesture input can change over time instead of remaining fixed. This discussion about unpredictability in instrument design is beyond the scope of this thesis, particularly since the intention in designing the AirSticks has been to make a rather predictable instrument, with one-to-one mappings that give the instrument high controllability and **transparency**. It is however worth keeping in mind this dichotomy as I did explore this unpredictability in most of the *Vacuum* mappings, to varying degrees of success, by having no control over what the other musician was playing in improvised contexts, and hence having little control over my sonic palette.

5.2.4 Performer Experience vs Audience Experience

There is one more dichotomy that is worth mentioning here which I'm labelling **performer experience** vs **audience experience**. Obviously these experiences are inherently linked, but there are situations where different performer experiences can equate to the one audience experience of a music performance. I am referring here to the performer experience of **miming** rather than actually playing, or in other words the degree of control the performer has over an instrument. A performer may move in exactly the same way through the music, essentially dancing to it, having no control over the sound, but still give the audience the same visual experience as if the sound was being controlled. This will be further investigated shortly when I discuss the notions of **magic** and illusion within new instrument design, but it is worth noting that the focus of this thesis is on performer experience, particularly for the performer to be able to interact and improvise with other performers within an ensemble.

Now that I have elaborated on the decisions that need to be made in choosing an acoustic instrument setup or a DMI template mapping, I want to return to the different approaches that I took in making these decisions, which in turn reveal different approaches to tackling the **mapping problem**.

5.3 Tackling the Mapping Problem

To begin this discussion, I want to return to some of the terms outlined in the opening chapter, particularly the different strengths inherent to acoustic and electronic instruments. I mentioned earlier that one of the major strengths of DMIs is their ability to decouple the connection between sound and movement. DMIs have:

'a separate gestural interface (or gestural controller unit) from a sound generation unit… The mapping layer refers to the liaison strategies between the outputs of the gestural controller and the input controls of the synthesis algorithm. This separation is impossible in the case of traditional acoustic instruments, where the gestural interface is also part of the sound production unit… Clearly, this separation of the DMI into two independent units is potentially capable of extrapolating the functionalities of a conventional musical instrument, the latter tied to physical constraints. On the other hand, basic characteristics of existing instruments may be lost and/or difficult to reproduce, such as tactile/force feedback.' (Wanderley 2001, p.634)

This paragraph greatly articulates the mapping problem. To add to this problem, DMIs provide extreme flexibility in offering endless sonic possibilities. These endless possibilities combined with the decoupling of sound and movement can lead instrument designers to a state of paralysis as they have infinitely more choices than with an acoustic instrument. To avoid this paralysis, I believe that instrument designers must first consider what they want the performance to sound OR look like. I am calling these categories **sound-first mapping** and **movement-first mapping**. Put most simply – do we prioritise sound or movement in a mapping? Do we listen to a sound and then imagine what movement goes with it, or do we make a gesture and then imagine the sound? Of course in some musical situations the mapping process starts with an idea of a sound, and in others with the movements, with the prioritisation of sound or movement shifting constantly. But to help us better understand the mapping problem, and hence be able to tackle it, it is worth isolating each of these approaches.

I would like to begin this next part of the discussion by playing to one of the greatest strengths of electronic music and electronic instruments – their use as a compositional tool.

5.4 Sound-first Mapping

5.4.1 Pressing play

'Music should be transmitted and not interpreted, because interpretation reveals the personality of the interpreter rather than that of the author, and who can guarantee that such an executant will reflect the author's vision without distortion?' (Stravinsky cited in Walls 2002, p.17)

The rise of electronic music, in particularly computer music, has given composers control over every nuance of the sound they wish to communicate to the audience. No more scores that are interpreted by musicians, no more limitations on sonic palette. The modern composer can control the setup of the speakers in the room, where the audience sit, the program they read, the temperature of room, hire helicopters (budget permitting), anything they believe needs to be controlled to communicate the experience they wish to communicate to the audience. If the most important aspect of the music for the composer is the sound itself, s/he may very well prefer to simply press play on a recording of the piece rather than risk a performer's mishandling of important instructions.

But if the composer wants to still have a performer involved in this performance, why not simply get a dancer to move in a way of the composer's choosing? The dancer will not affect the sound of the music in any way as they have no control over it, but they will simply add to the performance by moving their body in a meaningful way to the sound. Here the composer is prioritising different elements of the performance: first the sound, and then the body movements of a dancer. The composer may give the dancer creative license to move as they wish, and improvise freely, or s/he may also want to create an illusion that the sound and movement are linked in some way, even if the dancer has no control over the sound whatsoever.

Let's say for example the dancer comes out holding a controller, presses play and the music starts. Now the dancer has one tiny bit of control over the music, and the relationship between this controller and the way it connects the dancer's movement to the sound is communicated to the audience. The controller in this case can be a prop, with the sound cue occurring at the sound desk by the engineer, but the illusion has been created and sold to the audience. It is up to each individual audience member to either believe in this connection or not. Now let's say this dancer comes out holding the AirSticks. S/he presses a button on the AirSticks and the music starts. Again, it is irrelevant whether the AirSticks are actually plugged in or not, the connection has been formed and it is up to the audience to be either believers or skeptics.

Let's take this hypothetical a little further and say that the audience understands how the AirSticks work – that they track certain movements of the dancer and allow the dancer to trigger different musical events with these movements, or at least that the audience is convinced that the AirSticks are capable of this. By simply holding the AirSticks, again without them even

being plugged in, the dancer can now choreograph movement to the piece, being completely liberated of actually controlling the music, but still being able to put a performance on where the audience believes that there is a true 'real-time' connection between movement and sound.

We call this type of performance 'miming,' and it comes with plenty of bad connotations and an air of 'cheating' the audience. However, it is something that musicians do all the time in music videos, and more and more often in live performances. This cheating only seems real when the musician has somehow lied to the audience. Slapstick comedian Rowan Atkinson performs a sketch where he mimes playing an invisible drum kit. [69] At no point is the audience convinced that his movements are actually causing the sound, nor does Atkinson try to sell his kind of magic or illusion, nor is the motion capture technology really advanced enough or more to the point popular enough for the audience to consider it a possibility. It is extremely entertaining and no one feels cheated.

Of course there is much to lose from a choreographed performance such as the one described above. It is arguably harder to sell a connection between sound and movement through just miming, as the timing of the movement has to be incredibly precise. But more importantly, the performer's experience is completely changed, and we lose the real connection that allows improvisation and interaction with other musicians and the audience in a live performance setting. A very specific performance piece has been created, not an instrument that can be used in other contexts. As mentioned earlier, the experience for the audience may be the same if the performer is miming or playing, but the experience for the performer is completely different. A performer miming can only perform movements that do not control the sound. A performer playing an instrument can improvise and use the instrument as a **tool for composition** outside the performance space.

What we gain from a choreographed performance such as this one is that the music isn't compromised in any way, and neither is the movement, except that they still appear to be creating the sound. I am not suggesting here that we need more mimed performances. I am suggesting that we do this kind of reverse engineering of sound to movement as an exercise to help us discover new ways of tackling the mapping problem. In freeing the performer from controlling the sound during the mapping process, complete attention and imagination can be put into how to move to the music, what **metaphors** to use and how to imagine the playing space. This exercise invites us to consider what the audience perceives as 'real' when watching a performance featuring an open-air controller. How can performers, composers and instrument designers working with open-air controllers use this form of **magic** and **illusion** in tackling the mapping problem? I will return to this question later, but now I would like to further break down the sound-first mapping approach.

[69] For a video of this act visit https://youtu.be/A_kloG2Z7tU

5.4.2 Revelations of Sound-First Mapping

In the field of instrument design, the mapping process more commonly begins with the movement creating some sort of sound. But when the sound comes first, we can use the term '**choreography**.' Though changing the trajectory of this mapping process does not solve the problem of how sounds should be mapped to movements, starting with a more complete composition as a target can inspire different ways of choreographing movement to sound. In projects such as *Silent Spring* and *Malarkey,* very rough compositions were written, then choreographed, mapped to the AirSticks, rehearsed and performed. Each performance was different, and would feed the next performance, sometimes going back and changing the choreography before going through the rest of this process again.

Figure 21. Composition led trajectory of the creative process.

The rough compositions in these projects were cut into short samples, or what some instrument designers refer to as 'chunks' (Godøy 2011; Godoy, Jensenius & Nymoen 2010; Schacher 2010). Any piece of electronic music can be cut into short segments or chunks, 'fragments of sound-action in the approximately 0.5 to 5 seconds range' (Godøy 2011, p.13). Godøy argues that 'relating what we hear to mental images of how we assume what we hear is produced, is a basic phenomenon of auditory perception and cognition in general' (Godøy 2011, p.14). When we hear the sound of someone knocking on wood or playing a snare with brushes we can easily attach a mental image to the sound. For example, with the *Four Tet* remix it was obvious for me, after listening to the original opening drum break of "*She Moves She"* and cutting it up into four short samples, that a strike through the air with my right hand should trigger a kick and that a strike through the air with my left hand should trigger the snare. I could visualise the arrangement of these samples in the playing space based on my mental image of where a kick (or low floor tom) and snare would be set up in a conventional drum kit and use the metaphor of a strike to create these sounds.

Similarly, in projects such as *Silent Spring* and *Malarkey,* where short themes were composed and then mapped on the AirSticks for further development, kick-like (low) and snare-like (high) sounds were placed in the playing space accordingly. But beyond simple placement of high and low pitched and the striking metaphor, how can sound-first mapping help create a more nuanced mapping? Unfortunately, with the AirSticks we don't have the technology to properly utilise sound-first mapping of chunks in a more nuanced way. I can imagine a system that records gestures as a performer mimes over a selection of chunks, and then turns this into a mapping, morphing between these chunks as the performing morphs between gestures.

It is our intention to make the AirSticks more conducive to this style of mapping. One program that has allowed performers to more easily map in this way is *Wekinator*, designed by Rebecca Fiebrink.

'By thinking about the mapping mechanism... as a closed 'black box', Wekinator allowed me to explore the parameter space in a more intuitive and natural way. In the past when I have really focused on trying to create an expressive mapping between inputs and outputs, I ended up spending so much time and energy on the mappings themselves that they started to eclipse the actually (sic) sonic result.' (Fiebrink et al. 2010, p.4)

Currently the AirSticks do not allow much control over the nuance of parameter control, especially not to the degree of *Wekinator*. Programs like *Junxion* by STEIM[70] (Visi 2017; Jensenius, Godøy & Wanderley 2005; Andersen 2004) and *AudioMulch*[71] by Ross Bencina (Bencina, Wilde & Langley 2008; Bencina 2005; Bencina 1998) also provide the 'choreographer' with graphs to map out spaces for manipulation. *Junxion* for example has a learn function for the rescaling, smoothing and compression of the movement data to parameter control (Visi, Schramm & Miranda 2014). *AudioMulch* provides an 'integrated solution, the Metasurface… [and] simplifies the process of designing mappings further for musicians *(*Mainsbridge & Beilharz 2014, p.111). *Wekinator* supports the real-time creation of mappings, and does so 'using a supervised learning paradigm: the user may iteratively create training examples of (gestural feature, sound parameter) pairs, train the algorithms, evaluate the resulting models via hands-on experimentation and objective accuracy metrics, modify the training examples and algorithms, and repeat' (Fiebrink et al. 2010, p.2).

The AirSticks currently utilise *Ableton Live* which does not allow this feature. It is our intention to make this a feature of custom software in the near future, and further develop it to allow a three-dimensional learn function for quick mapping of the playing space. The ability to make quick meaningful mappings of specific movements to specific parameters is a very empowering feature for a gestural instrument to have, particularly when composition is followed by choreography and then mapping as described above. Imagine being able to record the way you move through space to a piece of music and then be able to not only recreate that piece by moving in a similar way, but also improvise with that mapping once it's created. On the official *Wekinator* website,[72] the write up claims that the software 'allows users to build new interactive systems by demonstrating human actions and computer responses, instead of writing programming code.' These are a type of tools that instrument designers need at their disposable to speed up the mapping process and to allow faster sound-first mapping approaches. No one would play the drums if it took them as long to tune as it does to make relevant changes to a mapping on the AirSticks. *Wekinator* and other similar projects are the

[70] For a short video about STEIM and *Junxion* visit https://vimeo.com/40155351
[71] For more visit http://www.audiomulch.com/
[72] For more visit http://www.wekinator.org/

tools we need for enabling us to speed up the mapping process and enter a new relationship with DMIs.

Sound-first mapping approaches can also be used to help map an entire piece, as opposed to just a section or short chunks. For example, although I did not actually make a mapping for "*Da Funk*," I did choreograph movements to it. I can imagine how every element of the sound would be created through movement. I chose this tune because I could visualise each of the elements of the song being played on the AirSticks. There weren't any vocals on this track, the melodic elements and rhythms were simple, and sections built in a seeming logical manner. Approaching the whole song in its entirety, as opposed to just considering a loop like in the *Four Tet* remix, was very interesting as it made me need to use more of the space around me, something that was beyond the current capabilities of the AirSticks. It is our intention to in the future develop new software that would allow us to use the choreography from the "*Da Funk"* project, save the movement information in time with the audio information and have the computer do all the mapping work in a similar fashion to *Wekinator* but tailored more to the gestures used on the AirSticks. Special attention would need to go into 'recording' the movements to sound in the most consistent way possible. The original sound would then be able to be generated through similar movements, or essentially 'remixed' with variations in the movement.

Even with the relatively primitive mapping capabilities of *CAMS*, many of my projects benefited from sound-first mapping. In "*CF1"* for example, I wanted to bring a pre-composed piece to life. The piece was cut into different chunks for each section and explored within these sections. Working with a choreographer on these sections opened me up to some new approaches to mapping. She would make me focus on certain gestures that pleased her eye, and incorporate more dance-like movements into the way I played the AirSticks. Some of these gestures would affect the sound, and others were purely figurative. This again leads us to the concepts of magic and illusion in tackling the mapping problem.

5.5 Magic & Illusion

As mentioned earlier, open-air controllers, since the invention of the *Theremin*, have been associated with magic, illusion, science fiction and the 'conjuring' of sounds out of 'thin air' (Rovan & Hayward 2000, p.1). These types of words are often used when a new technology comes into use that an audience cannot yet comprehend. The *Telharmonium*, for example, an early electric organ invented in 1896, was ascribed 'magical effects, stirrings of the blood, sublime joy, and spiritual intoxication' (Weidenaar 1995, p.11), but now does not carry the same divine characteristics to our ears.

Nowadays it's harder to 'wow' people with new technological discoveries; most people walk around with powerful computers in their pockets. But open-air controllers still have a magic to them, even if it isn't divine, and many designers of open-air instruments try to harness this magic in some way. The word 'magic' has even been used in the naming of a new gestural design tool, *MAGIC*, (Ashbrook & Starner 2010) and an interactive environment, *Magic Carpet* (Paradiso et al. 1997).

After one certain live improvisation on the AirSticks, the performance was described by a fellow drummer as 'witchcraft.' Many audience members, particularly those who witness a performance on the AirSticks for the first time, spend much of the performance trying to figure out how the instrument works. It was common for audience members after a performance to ask, 'Do you use cameras? Are those controllers Wii remotes? What do those buttons do?' Others, such as the Sydney Morning Herald's music critic John Shand, seemed to not want to know the 'hows' and 'whats' but instead praised the 'sheer unpredictability and unaccountability of the sounds' in 'Alon Ilsar's ingenious use of electronics.'[73] One collaborator I spoke to informally after an improvisation asked me not to tell him anything about any of the workings of the AirSticks, he thought it would ruin the experience. Just like with card tricks, there are people who want to know the secrets of the magician and those who would prefer not to know. Similarly, there are magicians who pride themselves on not giving away their tricks, while others believe sharing the secrets of their ways is their duty.

To maintain this analogy between the magic of the AirSticks and more traditional magic tricks, it was interesting to note the fine difference between questions like, 'Was there a backing track?' and 'How were you doing that?' The former seems to imply that there was some of kind of cheating going on, or that the trick is something anyone can do, whereas the latter implies some sort of virtuosity in either the playing and/or design of the instrument, like skillful sleight of hand.

As mentioned earlier, belief is at the heart of the audience's experience of such a performance. But the instrument designer can choose to play with the audience's idea of what is 'real.' With acoustic instruments, everything has a 'realness' to it as the connection of movement and sound is based in the physical real world. But with electronic instruments this

[73] For full review visit http://www.smh.com.au/entertainment/music/ellen-kirkwood-review-china-mievilles-weird-work-looms-large-in-music-20151111-gkvwv5.html

connection is broken, and can be reinvented by the instrument designer to play with the audience's perception of what is real. I have investigated the 'remapping' of this connection to varying degrees of success with the AirSticks. These investigations include playing with the inherent disembodiment of sound, physicalising sound, and subverting realness. These all deal with the notion of magic in some form.

5.5.1 Disembodied Sound

Electronic music inherently distances the sound from its sound source. With an acoustic performance, all sound comes from the source where the movement occurred, but with electronic music, the movement and the sound source can also be completely disconnected. This is part of the reason that early electronic music was considered so magical or ghostly. Not only can electronic music play with the relationship of sound with space or direction, it can also play with the relationship of sound with time. Echoes, delays, loops, **sustain methods**, all stretch the existence of sound across time.

To harness these ethereal qualities of electronic music on the AirSticks, I made several mapping decisions based on this disembodiment of sound. One simple mapping solution to play with space was to pan sounds according to where my hands were pointing, a mapping technique also taken by Imogen Heap (Mitchell, Madgwick & Heap 2012). I took this a step further in a piece which I will discuss more in the Future Work section, by using an array of 8 speakers set up in front, behind and above the audience, and using gestures to move sounds around the space as they morph. This 'immersion' of the audience can be taken further still by using a technique such as timbral spacialisation, most commonly used in electro-acoustic music performances, which uses a 'signal processing technique that involves the spatial treatment of all individual spectral bands extracted from a source sound' (James & Hope 2013, p. 77).

It was in fact in electro-acoustic improvisations and compositions where I could really play with this disembodiment and utilise my gestural controllers, as the audience could take the journey with the performers of the acoustic sounds firstly being represented in one sound source, let's say the vocal chords, and then being heard out of different speakers as different movements on the AirSticks were made.

My point here is that as instrument designers and performers, we should consider how the audience may perceive the relationship we map between movement and sound. An electronic instrument that allows the performer to take the audience on the journey of sound in space and time through movements, and allows them to both believe and feel some sort of magic, is a truly powerful tool.

5.5.2 Subverting Realness

Another way of taking the audience on a journey is to set up their expectations and then play with them. This can be done by mapping movements to sound in as 'real' a way as possible, creating an imaginary world around the performer based in the physicality of the real world. 'Electronic music often lacks a point of comparison with the natural world of sounds, providing

a largely mental and imaginative experience' (Hope & Ryan 2014, p.106). Adhering to the physical laws of gravity and other forces helps to take the audience to this other world or imaginative experience. Once this world is created, it can be subverted in playful and magical ways. For example, striking through the air may trigger a sample of water splashing at the beginning of a piece, establishing an imaginary world based on the real world. The audience can begin to imagine the water around the performer. But then the performer can subvert this image, and play with water in ways that are impossible in the real world. This is another type of mapping approach that can be added to the arsenal of the instrument designer.

5.5.3 Physicalising Sound

One way that many people talk about open-air controllers is that they allow the performer to grab sounds, or throw them, or **squeeze** them. These 'abstract concepts like time and space … are grounded in sensorimotor experience' (Wessel & Wright 2002, p.3). This physicalising of sound is another element that is very interesting to explore within the mapping process. One mapping allowed me to loop an acoustic instrument with the AirSticks and assign different ways of manipulating that loop with one of the hands, recording the loop with a button on that hand, filtering the sound by rotating around the z-axis and chopping the sound up by squeezing the trigger button. This creates a sensation that the loop could somehow be grabbed and exist in a physical form in my hand. Moving the hand and fingers could change and augment the physical and sonic properties of this sound. Shifting my gaze to the hand helped communicate this physicalisation further. Combining this with lights and different hardware solutions can really help illustrate this grabbing of sound, both for the performer and the audience. I will discuss these ideas in more detail in the next chapter. But now I will move onto a discussion on movement-first mapping.

5.6 Movement-first Mapping

The opposite approach to sound-first mapping is movement-first mapping, where a movement is made and then a sound is imagined. With sound-first mapping we can take any recorded or electronic sound, whether previously attached to a physical movement or not, and imagine what movement could create it. We are not restricted by properties of acoustic sound whatsoever. With movement-first mapping we are only restricted by what movements are physically possible for us to make, and by the motion capture technology we have at our disposal. Utilising this motion capture technology we can take these movements and convert them to sound in real time. But how do we begin to choose a sound for particular movements?

Many instrument designers take their inspiration from traditional acoustic instruments and the natural properties of acoustic sound and its relationship to movement. We experience that a big quick movement such as a strike creates a loud sharp sound, and that small slow movement such as a bow creates a soft long sound. This understanding of the physical world and the natural relationship between sound and movement is what some scholars call 'literature' (Fels, Gadd & Mulder 2002). The most common source of 'literature' on the relationship between movement and sound in instrument design can be found in investigating traditional acoustic instruments. Instrument designers 'resist the temptation of [simply] imitating the world of acoustic instruments' (Magnusson & Mendieta 2007, p.94), but instead use different metaphors of playing acoustic instruments to inspire their movement-first mappings.

5.6.1 Mapping by Metaphor

'Metaphor enables device designers, players, and audience to refer to elements that are; common knowledge' or cultural bases which we call literature. By grounding a mapping in the literature, it is made transparent to all parties. Metaphor restricts and defines the mapping of a new device. Through metaphor, transparency increases, making the device more expressive.' (Fels, Gadd & Mulder 2002, p.2)

Using the common knowledge that a strike through the air represents a percussive sound, we can build on the metaphor of playing the drums to help map the AirSticks. This use of a percussion instrument metaphor also helps to improve transparency for an audience aware of the way percussion instruments work and grounds the workings of the instrument in the physical system of our acoustic world (Fels, Gadd & Mulder 2002). Utilising the motor skills of an expert percussionist can also lower the entry level of the instrument, allowing focus to shift from learning to play the basic elements of the instrument to mastering it (Mulder 2000). 'Computer interfaces that are closely modeled on existing acoustic instruments can reduce the learning curve for those performers who are experienced on the acoustic counterpart, tap into the existing resource of performers' virtuosic skill, and become readily usable by a larger pool of performers compared to more novel interfaces' (Dobrian & Koppelman 2006, p.4).

However, there are many challenges to making an instrument 'seem natural and intuitive,' and learnability must be balanced against expression in most mapping situations (Dobrian & Koppelman 2006). Also, if a metaphor is taken too far, then no new instrument is created. All that is created is simply a mimicked version of an existing one.

As stated earlier, it has never been my intention with the AirSticks to make an electronic drum kit to replace electronic pads or acoustic percussion, but instead to make a new and original gestural electronic instrument for percussionists. The intention was to take the physicality of the drums and then decide what those movements should sound like, a process I am describing here as movement-first mapping. This allows a starting point not only for the performer, but also for the collaborators, as one pointed out.

Collaborator 1: *I think I'd need to play with you more to really understand what the mapping is doing. Because when I understand what the mapping is doing and I understand what you are actually playing, it would be like watching a violinist play, or a drummer play. You know when the drummer is playing the toms, you can see what they are doing, or when they are hitting a cymbal. Whereas with the AirSticks I can't see how the space relates to the sound yet. All I can see is that if you wave your arms around there tends to be more intensity. Or if you hit at a certain rate, it's more like a rhythm. So... Um... being able to read where on your spatial map those different sounds are and having that quite clear so if you move over there I can hear... I can hear that you are moving onto the toms or an equivalent drum kit or I can see that you are about to hit a cymbal or something.*

Me*:* *You'd like it to be more like a drum kit even though it doesn't sound like a drum kit?*

Collaborator 1*:* *No, I'm just using that metaphor for you.*

Using metaphor this way as a starting point not only helps the other musician feel connected to the music, but also helps the audience understand how the movement and sound are related. Once this drumming metaphor is used to create the basics of the instrument, other movements can be developed around this metaphor. In all the ideas for future hardware, discussed in more detail later, special consideration was taken for how confidently and easily an expert percussionist could play the AirSticks on their first attempt and then build on this knowledge in an intuitive way.

With the current hardware for the AirSticks, since there is no haptic or tactile response, this initial transfer of motor skills is not as fluid as one would hope, but it does allow the performer to be able to control sound in a very different way to traditional percussion. The metaphor of a strike extends past that of simply creating a sharp percussive sound to also being able to control the length of the sound with the one movement. No acoustic percussion instrument allows the control of note length in this way short of choking a cymbal or using a sustain pedal. Furthermore, sustain on the AirSticks, like that on a keyboard synthesiser and many other electronic instruments, continues without the performer putting any more energy

into the sound; energy is needed to stop the sound. Here another more abstract metaphor is used in the mapping of the AirSticks: 'freezing,' not to be confusing with the freezing of an instrument to give it constraints.

This is one of the best examples of movement-first mapping that was used in the process of mapping the AirSticks. After settling on the metaphor of playing the drums as the core movement of playing the AirSticks, we realised that other movements, particularly of remaining motionless after a strike, were becoming byproducts of striking and slashing through the air. We began imagining what sound could be related to this motionlessness and started to investigate ways of 'freezing' the sound, mostly through spectral freeze.

Another movement by metaphor, that of turning an imaginary knob by rotating the hand on the z-axis, also inspired a change in sound. I imagined a low-pass filter on the wrist rotation inwards and a high-pass filter on the wrist rotation outwards. Again, the sound, or change in sound in this case, was inspired by the movement.

Another movement I had access to once a sound was triggered was rotation on the y-axis. This movement seemed fitting for panning, as the movement implied pointing to the left or right.

These are all very basic examples of movement-first mapping. The extreme movement-first mapping situation occurs when a dancer choreographs in silence and later begins to imagine what sound would work best for their movements. Indeed, much dance choreography is done in this way, where music is brought in after the movements have been created, sometimes by a composer who has seen the choreography. What can we learn from this extreme example of movement-first mapping? How do we even begin to imagine the appropriate sound for these movements? While detailed consideration of these complex concepts is beyond the scope of this thesis, I believe they are becoming increasingly relevant to electronic musicians who are concerned with gesture. Having worked with choreographers and dancers over the course of developing the AirSticks, I have encountered some interesting ways that these movement-focused artists work, which could help instrument designers make more expressive instruments.

One discussion I had with a choreographer about dancer's movements being captured and converted into sound led me to consider how different the approaches of musicians and dancers are to movement and sound. In general musicians lead with sound, and dancers with movement. In this way dancers are liberated to move as freely as they wish, and musicians need not really consider what they look like when creating music. Asking a dancer to control sound would surely restrict their ability to express themselves through movement, just like asking a musician to move in certain ways while playing restricts their ability to express themselves through sound. But I believe it is the bringing together of these two very different approaches to movement and sound that can lead to the most interesting mappings.

Returning to the case study of "*CF1*," in which I worked with a choreographer to bring a pre-existing piece of computer music to life, the choreographer brought ideas and metaphors from the world of dance which musicians and instrument designers seem not to often consider. These more non-musical and often more abstract metaphors like pouring water and playing an

invisible stream, or bringing a sound towards the body to turn its volume up, or stirring a giant vat of sonic broth. These ideas can be used to help expand the mapping of an instrument beyond the realms of simply designing an electronic instrument based on an acoustic one. In bringing in these other non-musical elements to the mapping of an instrument we may also begin to consider not only movement metaphors, but also transport the performer to different virtual or imagined spaces.

5.6.2 Mapping a Virtual Space

The AirSticks, as all open-air controllers, invite the performer and audience to use their imagination in ways that acoustic instruments, or even electronic pads, have not done in the past. Consequently, the playing space around the performer can become a virtual or imagined space. One obvious way of exploring this space meaningfully with the AirSticks, fitting into the metaphor of drumming, is to map a layering of a drum kit onto this space: kick drum at the bottom, snare in the middle, cymbals up top.

The AirSticks allow the easy manipulation of this space, moving drums around to places they would not usually be, or changing between different sounds with different approaches to the trigger point. For example, in *Silent Spring's "Dawn*," striking through the air with the palm facing up triggered a sound resembling a kick drum, but striking that same area with the palm facing down triggered a snare sound, with the sounds morphing between each other across this z-rotation.

Forming continuity between these sounds is a great advantage of open-air controllers. The attack of sounds can 'crossfade' into the attack of the sound adjacent to it, as opposed to jumping to the other sound. As mentioned earlier, one of the greatest advantages of the AirSticks triggering system is the ability, not given by conventional electronic pads, to control the sustain of sounds. This sustain function opens up the possibility of triggering longer tones or samples and manipulating them after the attack is triggered. This sustain can also be used to morph between sounds, taking the listener from one imaginary space to another, morphing between a drum kit and a piano, for example.

Another exciting and less obvious approach to mapping the space around the performer, touched upon in the section about magic, is putting the performer in a non-musical situation. Going back to my roots as an acoustic percussionist, I love exploring any real space for percussion sounds, whether sitting on sand, or in a pool of water, or playing with coins on a table. There seems to be an audience appreciation for musical live 'foley' of this kind. Within electronic music too, there is a tradition of manipulating common objects such as biscuit tins and bottles in making music[74], for example at the *BBC Radiophonic Workshop* with particular reference to '[John] Baker's virtuosic ability to splice the tiniest pieces of tape to create elaborate rhythmic patterns' (Niebur 2010, p.124).

With the AirSticks, samples of splashing and pouring water can be utilised to create a

[74] For a video of BBC Radiophonic Workshop composers discussing their craft visit https://youtu.be/YW8TdMgSxaQ?t=1m10s

virtual space around the performer that mimics a real space. But unlike the real space, this space can be manipulated and reassembled in a creative way. This kind of mapping could also be set up in an installation, where members of the public can have a go at playing their own virtual space. This virtual space can also extend beyond the reach of the performer. In the case study "*H2.0"* for example, I became a conductor of a virtual choir projected onto twelve face-shaped screens. In this piece, the virtual space extended beyond the conventional playing space and onto the visuals.

Indeed the *Razer Hydra* gaming controllers used as the AirSticks were designed for high-end virtual reality gaming. My experience with the AirSticks suggests that it is worth considering virtual spaces as a way of tackling the mapping problem, particularly if it is the intention of the instrument designer to prioritise transparency and theatricality. However, if the instrument designer is looking to attain more controllability, expression and efficiency, subtle movements, often hidden from the audience, may be considered.

5.6.3 Mapping Discreet Movements

Since the current hardware for the AirSticks come in the form of gaming controllers, it invites the use of thumb joysticks, triggers and bumper buttons. These subtle and discreet movements can be utilised for mode changes and understated manipulations. However, the more a mapping relies on them, the more the interface merges with ones like the mouse and keypad, the exact interfaces that the AirSticks are attempting to supersede. Discreet movements may give the performer more control over subtle parameters, perhaps leading to a more expressive experience for the performer, but these discreet movements start to hide the correlation between the performer's movement and sound. Having said that, the button accordion for example relies on little buttons for its playing, but the audience often knows enough about the workings of such an acoustic instrument to feel a sense of virtuosity and expression in the way the musician plays and moves with the instrument. Similarly, with the use of close up camera angles and/or visualisation systems, these subtle movements can be more openly communicated and displayed to the audience. I will elaborate on some ways of communicating and displaying these movements further, both for the audience and the performer, in the next chapter.

It could be argued that often it is not transparency that the audience is looking for in a performance, but rather the expressive facial and bodily movements of the performer that surround the more discreet movements of playing the instrument. The audience's connection to the performer's movements, whether relevant for making the music or not, is what draws them into the performance. Pierre Hérbert's philosophy is that '…the measure of a work of art is whether one can sense in it the presence of the artist's body' (Ostertag 2002, p.11). This is not only true of music, but is often discussed in reference to the success of painters such as Jackson Pollock, where the artist's movement is inherent in the blots and splashes of the artwork.[75] 'These artists painted in a way that was spectacular to witness – full of action, movement and

[75] For an example in his work "*Autumn Rhythm (Number 30)*." For more visit https://www.metmuseum.org/toah/works-of-art/57.92/

drama…' (Hope & Ryan 2014, p.85).

When mapping a DMI, the instrument designer can decide how much energy the performer must put into the system to create sound, or how much to liberate the performer from having to move to create the desired sound, leaving room for the performer to move and communicate the music to the audience in other ways. This latter form of mapping is particularly common in popular electronic dance music performance, where performers often simply press play and occasionally make some discreet knob twiddling and fader pushing in amongst jumping around and putting their hands in the air. As will be discussed in the next chapter, one of desires for the AirSticks is to enable these knob twiddles and fader pushes in such performances to be replaced by bigger and more transparent gestures. This is a mapping consideration that is relatively specific to the genre of electronic dance music, which leads to another approach to tackling the mapping problem: genre-specific mapping.

5.7 Genre-specific Mapping

In this section I consider what genres of music play to the strengths of the AirSticks. Just as a drum kit has its place in rock'n'roll and jazz, but not in Baroque or Indian classical music, contemplating the most appropriate and relevant genres of music that the AirSticks could work within can help to give the mapping of an instrument more direction and focus, concentrating on the inherent advantages of the interface. It is worth noting the three genres investigated here also fall in line to my own aesthetic. Other performers may find playing other genres on the AirSticks just as appropriate.

5.7.1 Wonky Beat

Wonky beat[76] is a new genre of music pioneered by electronic producers such as *Flying Lotus*[77] who fuse dubstep sounds with hip hop, or specifically glitch hop, beats often inspired by the earlier music production of *Madlib*[78] and *J Dilla.*[79] These grooves are often off the grid, or unquantised, moving strong beats, particularly kicks and snares, either early or late in relation to other sounds. This can be thought of as electronic music with a swing, bringing back full circle the development of hip hop, from sampling full breaks of acoustic drummers, to quantising each individual sample, to replacing these with electronic sounds, and most recently to reintroducing the human feel of the original break but with individual electronic sounds. Wonky beat artists such as *Samiyam*[80] go as far as often playing in their drum samples on triggers without regard for the grid at all, though usually this 'human feel' is looped over a one or two bar phrase. Arguably the earliest pop tune with this kind of groove was "*What About Us"* by *Brandy,*[81] but most recently artists such as *D'Angelo,*[82] *Kendrick Lamar*[83] *and Erykah Babu*[84] have produced tracks with many features of this genre. Other features of wonky beat are heavy sidechain compression, mid-range basses using pitch bending, LFOs affecting low-passing and high-passing filters, phasing, and delays.

Of particular interest is the relationship in this music between drummers and producers. Drummers such as *?uestlove*,[85] *Chris Dave*[86] and *Karriem Riggins,*[87] all of who have played and recorded with *Erykah Badu* or *D'Angelo*, are often credited with evolving the genre. They involve themselves in much of the production and inspire a more complex analysis of the grooves, placing importance not only on a consistent human wonky feel, but also an

[76] For more visit https://rateyourmusic.com/genre/Wonky/
[77] For an example of a *wonky beat* track by *Flying Lotus* visit https://youtu.be/0ScYz9sNaQk
[78] For an example of *Madlib's* production visit https://youtu.be/apN0AXjJxQE
[79] For an example of *J Dilla's* production visit https://youtu.be/DhCmyUUD1c4
[80] For an example of a *wonky beat* track by *Samiyam* visit https://youtu.be/cfPRCVN_5iw
[81] To listen to this song, visit https://youtu.be/ALEmbB4c7yI
[82] For an example of a *wonky beat* track by *D'Angelo* visit https://youtu.be/eT75hdcOOkU
[83] For an example of a *wonky beat* track by *Kendrick Lamar* https://youtu.be/f65mFjQy1K8
[84] For an example of a *wonky beat* track by *Erykah Badu* https://youtu.be/XykIswFgLpU
[85] For an interview *?uestlove* discussing working with *D'Angelo* visit https://youtu.be/uAXJ-3dAMH8
[86] For *Chris Dave* paying tribute to *J Dilla* visit https://youtu.be/l3TPStb8CoE
[87] For an example of the production and drumming of *Karriem Riggins* visit https://youtu.be/jWWvvFSeXIg

understanding of less common subdivisions such as quintuplets and septuplets to attain this feel through a different process.[88]

The AirSticks can be used within this genre to create these wonky beats, played and manipulated in real time, replacing many of these LFOs with oscillating body movements and bringing back the original swing of the drummers sampled from early hip hop. Tracks like "*Deep Fried"* and "*Level Up"* from *the Sticks* debut album are examples of the way the AirSticks have been used to improvise, compose and perform within this genre. The strong presence of spacious kicks and snares in this music allow the time to give nuanced and subtle variations to each strike. This plays into the strengths of the AirSticks making the focus on precision and detail of each gesture as opposed to speed, which as discussed earlier is harder to attain on an instrument without haptic or tactile feedback (Young, Murphy & Weeter 2017).

When mapping for *the Sticks* Dock residency, I considered this genre and listened to the detail in its hi-hat and percussion patterns. I would often use the *Arp* function to fade in various, shifting pulses, and occasionally lock into them as quintuplets or septuplets. I would then negotiate how to play against them with the kick and snare pattern. I found this very fulfilling in improvised situations, and it inspired the discovery of many new feels and grooves. In *the Sticks* Dock performances, we would frequently set out to improvise around this genre, but would often find ourselves in territories that we would not define as wonky beat or hip hop. Though genre conventions can often block originality, loosely considering a genre of music when mapping an instrument can help inspire original ideas. And it was this search for new sounds and genres that inspires *the Sticks'* exploratory improvisations most.

5.7.2 Drone Music

Although perhaps not as visually inspiring as wonky beat, *drone* music falls in line with some of the other advantages of the AirSticks. *Drone* music relies on very slow movements: slow pulses, slight variations in harmonic content, long reverbs.[89] Several drone pieces have been improvised and composed with the *Vacuum* mapping for the AirSticks, most satisfyingly "*Air Vacuum"* and associated pieces such as "*Robotross Part 1"* by *Faulkland*, and more recently in collaborations with synth player Travis Austin (a project called *Velize*) and harmonium player David Grubbs.[90]

The focus with most of these *drone* pieces has been the sound, often leading to slow minimal movements in the live performances. Instead of striking through the air, the template mapping for drone performances takes inspiration from bowing and percussive brush work. There have been discussions with a martial art expert to incorporate movements from tai chi and qigong into such a mapping, maintaining the stillness in the sound with stillness in movement. Similar ideas have been investigated by the creators of *Sonic Tai Chi*, Joanne Jakovich and Kirsty Beilharz (Jakovich & Beilharz 2007). They 'were motivated by a desire to

[88] For an example of *Chris Dave* playing these less common rhythms visit https://youtu.be/t-e4YJ-3Cb0
[89] For an example of *drone* music visit https://youtu.be/WehUGlNY-SY
[90] To listen, visit https://velize.bandcamp.com/album/extravegetal-arms

understand how digitally generated spatial elements, such as sound and image, could be controlled by users of a space to create novel environments' (Bilda, Costello & Amitani 2006, p.228).

There have also been ideas to make further mappings for *drone* pieces, ones that require the performer to move more energetically to maintain the drone, using the metaphor of a hurdy-gurdy for example. This mapping hopes to create juxtaposition between movement and sound, going against the more obvious slow movements of *drone* music.

Much of the *drone* music I have made with the AirSticks could also be considered electro-acoustic in nature.

5.7.3 Electro-acoustic Music

Electro-acoustic music has its roots in early tape music composition. The acoustic musician or musicians would often play along to a score accompanied by a backing track. In recent years the acoustic musicians are sometimes taken out of the equation completely, with composers deciding to present their music in a surround sound array.

Open-air controllers lend themselves well to adding a live performance element to this genre of music, allowing the physical performance of these 'backing tracks.' The process of live sampling, looping and manipulation of the acoustic elements can be performed, presented and communicated to the audience through body movement. This also enables the performers to improvise. In designing this kind of mapping for the AirSticks, 'the instrument's responsiveness to its acoustic environment, how it reacts to other instruments and how it reacts to the physical aspects of performing' (Bailey 1993, p.100), was considered, often creating a relatively unpredictable mapping that could invite further improvisation.

Most electro-acoustic processing done within improvisations is done with the aid of laptops, most famously in Evan Parker's *Electro-Acoustic Ensemble*.[91] The AirSticks lend themselves to replacing the interface of the mouse and keyboard in the role of sampling and manipulating the acoustic instruments in an improvisation. For example, one collaborator compared her experiences improvising with a laptop musician against improvising with the AirSticks.

Collaborator 1*: 'The gestural elements of the instrument are really quite powerful. And the reason why they are powerful is because they cue me... the intensity of your movements reflect the sound, so sometimes you are waving your arms around quite fast, and you're doing a beat, or… I can see what you are doing, so in that way it's like an acoustic instrument and it's much more... informative for me. I feel like I am playing with someone, whereas if you are playing from behind a laptop it is much more one sided. It's not nearly as inspiring for the improvisation I think.'*

This highlights that even if a collaborating musician is not shown exactly how the gestures on

[91] For an example visit https://youtu.be/6owYhb096gc

an instrument relate to its sonic output, having some sort of physicality to an instrument can help communicate more abstract elements of the music like intensity and feel. The gestural element not only helps the audience digest the process of making the music, but it also facilitates cuing and interplay between electronic and acoustic musicians as discussed in the *Silent Spring* case study.

'Experimental improvised music is music that turns unexpectedly, leaping abruptly and uncontrollably away from conventions; it is music gone astray… It is the joy of social interplay that lies beneath the pathological impulse among most experimental improvisers to play with as many people in as many situations as possible.' (Arias 2002, p.31)

The **collaborative** nature of improvisational electro-acoustic music invites much social interplay, which leads us to the last mapping consideration of this discussion section, that of **mapping for ensemble playing**.

5.8 Mapping for Ensemble Playing

As discussed in the section on the one-person band dilemma, the transition between working in solitude on the design of an instrument and having it ready for ensemble playing is a difficult but very satisfying one. For such musicians as Earle Brown,[92] the process of collaborating with other musicians in the field of electronic music is a lot more fulfilling than the common approach of cutting up samples in a studio, as he explains in an interview with Derek Bailey.

'...I found it very boring just to sit down in the studio and cut and splice tape and combine these things. I mean I really like the society of making music with people…' (Bailey 1993, p.64)

Since the earliest mappings of the AirSticks, the template mappings have been developing in two ways to accommodate different types of collaboration. One use of the mapping is for improvisation and the exploration of compositional ideas, another is for the performance of a composition itself. As mentioned earlier, I believe that using new instruments in more collaborative contexts across both the improvising and composing streams of music can help promote the culture of new instruments more rapidly and bring more attention to the design of new instruments for high-level social interplay, in turn discovering new approaches to tackling the mapping problem.

When mapping for ensemble playing, particularly with the intention to improvise, it is important to take into consideration what the collaborators expect from the new instrument. In many of the musical situations I found myself in, I could not change the mapping of the AirSticks quickly enough to accommodate the more specific desires of the collaborators, not to mention my own. In a rehearsal situation, there is no time to put the AirSticks down and change mappings manually on the computer with a keyboard and mouse. In recent months I began developing ways of changing and saving certain mapping settings without putting the controllers down. An ultimate goal with the AirSticks being an ensemble instrument is making it as easy to 'tune' as an acoustic instrument, where the tuning capabilities utilise the extreme flexibility of the instrument. Using the controllers to speed up the mapping process, and hence the design and composition process too, can lead to the mapping of the instrument itself becoming part of the performance. This is an element of the instrument I would like to expand on much further. I have touched upon this function a bit through this Discussion chapter and will elaborate on it a little further in the next chapter.

Being bounded by the limitation of needing to map the instrument with a keyboard and mouse led me to many constraints within ensemble playing. I made sure to communicate the limitations of the mapping to the other musicians when possible. When playing on an acoustic kit within an ensemble, my role is more or less defined, and the musicians I play with would know more or less the limitations of the instrument. They can often communicate a specific desire with relative ease. But on an undefined instrument such as the AirSticks, bandleaders

[92] For more information visit http://www.earle-brown.org/

were often uncertain how much to ask for. I would often reiterate to my collaborators that anything was possible, but that certain ideas would take longer than others to implement. This interaction and discussion with collaborators often led to new ways of thinking. Sometimes ideas could be pursued further, if the time permitted, and other times these ideas would be simply noted with the hope of exploring them at another time. Mapping for ensemble playing, and indeed taking time to improvise, rehearse, compose and perform with a diverse range of artists, is an invaluable source of inspiration for helping to overcome creative paralysis. Knowing that collaborators will be intimately responding to your mapping and having several deadlines to adhere to in preparation for public performances leaves no space and time to get stuck dwelling in mapping possibilities. I believe ensemble playing has been my best cure for creative paralysis.

5.9 Conclusion

In this last section I have highlighted some effective ways of overcoming creative paralysis in tackling the mapping problem. These approaches mostly focus around how to get started in preparing to map a DMI and included sound-first mapping, movement-first mapping, the use of magic and illusion, genre-specific mapping and mapping for ensemble playing

I have also highlighted some effective ways to:

- utilise the existing motor skills of expert drummers in designing a truly new instrument, not an augmented drum kit, that allows the control of complex sound textures at the same time as allowing the execution of precise rhythmic gestures in reaction to other performers;
- utilise the latest in motion capture technology in the design of a new instrument that can be used not only to perform electronic music, but also as a tool for improvisation and composition within an ensemble; and,
- facilitate more satisfying collaborations between electronic musicians and acoustic musicians, visual artists and physical performers without technology hindering the creative process.

These approaches have also inspired new ideas in the development of the AirSticks, both in the design of future hardware and software. Since I have been focusing throughout this thesis on creating a new instrument for live electronic percussion, I will now outline the design criteria for a new more refined version of the AirSticks.

Chapter 6:

Future Work

6.1 Introduction

In this chapter I want to present new detailed design criteria for future software and hardware for the AirSticks within and beyond my own creative practice. This chapter will be split into three sections. In the first section I will outline the design of new software and hardware for a version of the AirSticks, intended for use in my own practice but also by other expert percussionists. In doing so, I will further address (Q1) *some effective ways to utilise the latest in motion capture technology and the existing motor skills of expert drummers in designing the AirSticks*. I understand that continuing to address research questions in a Future Work section is unconventional, but since this project is an ongoing one, and since developments in motion capture technology continue to occur, I think it is of value to reiterate these research questions here.

Through the keeping of meticulous notes and weekly meetings with co-designer Mark Havryliv, a set of major considerations in designing the AirSticks 2.0 have emerged, which directly reflect concepts brought up in the Discussion chapter. I will outline the design criteria for a new instrument with the working title, the *Sweatbands*. The hardware for this instrument focuses on creating a better tactile response than that possible with the use of the Razer Hydra and software introduces several new functions that were not attainable through CAMS.

In the second section, I will briefly outline some more ideas for the AirSticks, enabling skill sets beyond my artistic practice. This section will bring up further research questions beyond the scope of this practice-based research.

Lastly, I bring the reader up to date with the latest projects involving the AirSticks that have emerged since the completion this thesis, and finish off by discussing the effects of the AirSticks on my acoustic drumming practice.

6.2 The Sweatbands

Having reflected upon several mappings used across dozens of projects on the AirSticks, Mark and I pursued the design of a new instrument. Once again, more specific design criteria for this instrument emerged as some criteria were compromised and restricted, while others strengthened. Changes to the initial design are as follow:

- Building on traditional drum practice incorporating all four limbs should be compromised to allow the performer to stand and use more of the playing space. Tactile, haptic and visual response should be built into the hardware to allow more fluid, accurate and fast playing.
- Triggering and manipulation of sounds in a 3D playing space around the performer using hand and finger movements should be restricted to synthesised sounds to limit or refine the sonic palette and give the instrument a stronger signature sound. Sound synthesis also allows the most nuanced control over several parameters of the sound, and smoother and more detailed sound morphing.
- Access to a plethora of mapping possibilities through a MIDI Trainer software and *Ableton Live* should be compromised to allow further fine 'tuning' of these synth sounds in the new standalone software. This tuning should be done with the controllers themselves, with much higher resolution, distancing the performer further from needing to access the computer.
- The physically plausible connection between movement and sound which could in turn be communicated to the audience and to other musicians in an ensemble should be strengthened further with the use of tactile, haptic and visualisation response built into the hardware.

Furthermore, **transparency**, **controllability** and **expressivity** should be prioritised even more so over flexibility in an attempt to design a truly new electronic instrument for percussionists – not just an augmented drum kit – that could allow the control of complex sound textures at the same time as allowing the execution of precise rhythmic gestures in reaction to other performers. **Learnability** should be enhanced as we focus on creating a more intuitive instrument to play with less use of the buttons. Again, we want the *Sweatbands* to be used not only to **perform** electronic music, but also as a tool for **improvisation** and **composition** within an **ensemble,** and to specifically bring a new particular sound to these ensembles. We also want it to facilitate more satisfying **collaborations** between electronic musicians and acoustic musicians, visual artists and physical performers without the technology hindering the creative process by allowing more simple and quick ways of changing or 'tuning' the instrument for different purposes. The custom hardware would also allow the performer to use their own drumsticks, and play acoustic percussion at the same time as the *Sweatbands*.

As discussed throughout this thesis, a major problem with the AirSticks has been deciding on a **sonic palette**. *CAMS* opened up a whole world of sonic possibilities within *Ableton Live*, but the AirSticks did not create a very identifiable sound. The hope with

restricting the sonic palette purely to sound **synthesis** is that the instrument could create a more identifiable sound and better implement the morphing of sounds in 3D space.

I will now outline the new software and hardware for the *Sweatbands*, and highlight how we intend to implement the design criteria.

6.2.1 The New Hardware

During the AirSticks project we have been using the *Razer Hydra* gaming controllers for reasons laid out throughout this thesis. These controllers do provide six degrees of freedom to work with, at very high accuracy, and also provide buttons to change modes. However, they do have several failings. The controllers are wired, break quite easily, are discontinued (only available second-hand on eBay), are made of plastic, do not respond well to sweat and provide no haptic, tactile or visual feedback.

Our new hardware is designed to be used with the performer's own drumsticks so that more of their drumming technique can be transferred to the instrument. The hardware will come in the form of a sweatband around the performer's wrist. All the motion capture sensors and necessary computer power will live on the upper side of the wrist. On the underside of the wrist, just below the palm, there will be a small mesh trigger pad, like that used in modern electronic drum kits. Holding the stick just 2 or 3 inches further up towards the tip will allow the back side of the drumstick to hit this pad. We have tested this system with some basic prototyping and found that this triggering system feels extremely similar to hitting a static percussion pad, barring some changes in stick's bounce response (see Figure 22 and video link on the next page). Further testing is currently underway.

This triggering system, or more appropriately this triggering mechanism, will allow the performer to play more fluidly, accurately and with more speed, while still being able to track the player's movements and trigger different sounds in a 3D playing space. It will also allow the performer to use the *Sweatbands* as part of their acoustic drum setup, as, unlike with the *Razer Hydras*, the performer can hold conventional drumsticks and can interchange between hitting an acoustic kit and the pad on their wrist at will.

This new trigger mechanism will also change the way the performer controls **sustain**. Since the *Sweatbands* rely on the physical hitting of a trigger pad for note-on information, we have added a new system for controlling and manipulating the sustain of sounds. If the performer wants to sustain a sound they can hold the stick against the trigger pad for as long as they desire. Pressing the stick harder against the pad – stretching the mesh skin of the pad – will result in a slight variation to the sustained sound, in the form of pitch bending for example.

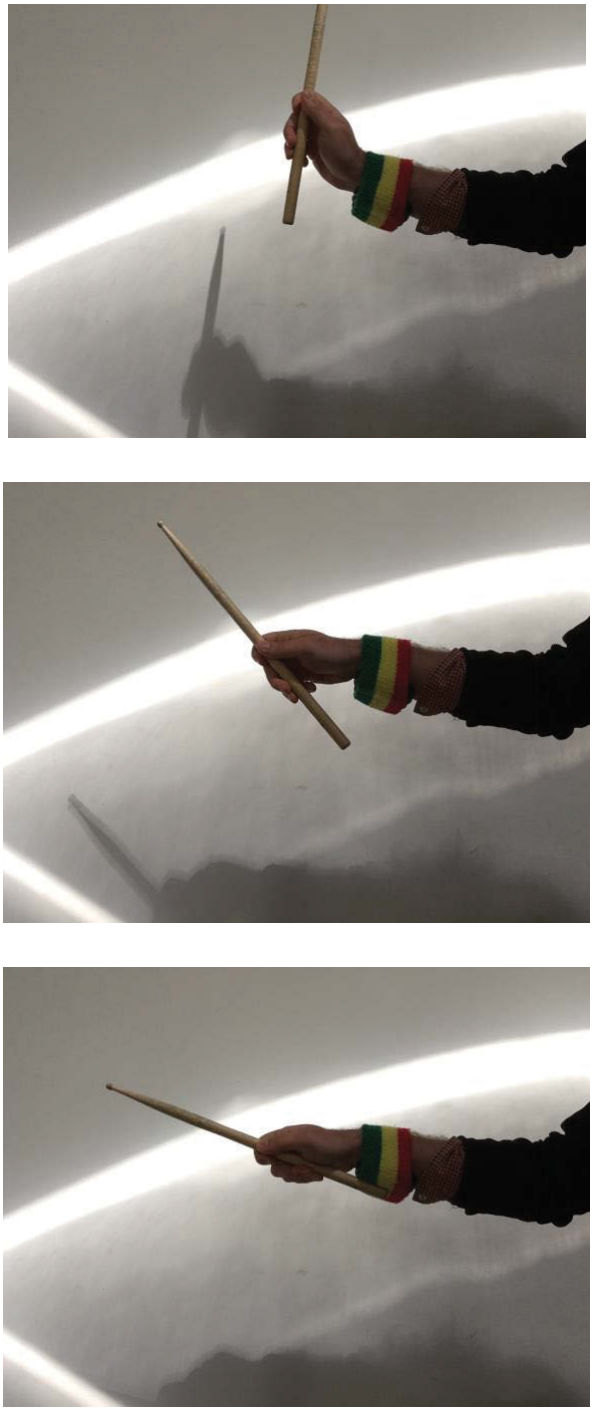


Figure 22. Prototyping the mechanism of triggering a sound by striking a pad under a sweatband with the back side of a drum stick.

The Sweatband Trial

https://youtu.be/ysDdeW_QuQs

Unfortunately, we may need to lose the use of button presses with the new hardware, as we are preferencing the feel and use of conventional drumsticks, though we may deploy some buttons on the upper side of the wrist for mode changes. We also are restricted by the motion capture technology we can deploy for the *Sweatbands*, as we a preferencing wireless

technology and our own custom hardware. This means, as with many new gestural controllers such as *Mi.Mu Gloves*, *MYO armband*[93] (Nymoen, Haugen & Jensenius 2015; Cabreira & Hwang 2015), *Hot Hand USB*[94] (Hantrakul & Kaczmarek 2014), *Gest*[95] and *WiiMote* controllers[96] (Paine 2009; Wong, Yuen, & Choy 2008), we will be relying on gyroscopes, accelerometers and magnetometers to provide us with motion capture data, and we must forgo absolute position tracking. This is future work, and we will need to be creative in the software design to still give the performer a feeling that they have six degrees of control. Lastly, we will add the use of LED lights to help visualise the sound for both the performer and audience.

This is just the first outline of the *Sweatbands* hardware, and we are sure to discover more as we begin to build prototypes, but we believe this design will deal with many of the shortcomings of the *Razer Hydra* gaming controllers.

6.2.2 The New Software

To implement the new design criteria above, we needed to create new software. Throughout this project I have been using *CAMS* which has allowed me to make several template mappings in *Ableton Live*. One template mapping that I have found myself returning to more and more was that first used in the *Nine Lives Live* project. This template mapping featured only **FM synthesis**, and no samples. While making this prototype I kept notes of shortcomings of using *CAMS*, both within the program itself, and within *Ableton Live*. Over the last year, Mark Havryliv and I have been designing and programming the *Sweatbands*' software from these notes. We are no longer designing software that simply outputs MIDI. We are making a standalone VST plugin programmed in *C++*. This will improve the instrument's resolution dramatically and give us much more control over specific functions. I will not go into the technical detail of the software here, but I do want to outline two of the software's functions in response to *CAMS*'s shortcomings. Each function will be described within its use in *Ableton Live*, and then fleshed out further for development in the *Sweatbands*. This software will be used with our own custom hardware outlined above, but has been prototyped on *Razer Hydra* gaming controllers.

Sustain and Morphing

As mentioned previously, the velocity of both downstrokes and upstrokes on the AirSticks can be used to control not only the volume and brightness of a sound, but also the attack and release of sounds. The sustain of the sound can also be controlled. However, most percussive samples are only short chunks of sound that do not have sustain. For this reason, synthesis seemed to be

[93] For an example of the *Myo armband* being used as a MIDI controller with *Ableton Live* visit https://youtu.be/MnIv9Wi26bc
[94] For an example of the *Hot Hand USB* being used as a MIDI controller with *Ableton Live* visit https://youtu.be/Q_WaIkXZ_V8
[95] For an example of the *Gest* controller being used as a MIDI controller with *Ableton Live* visit https://vimeo.com/146978739
[96] For an example of the WiiMote controllers being used as a MIDI controller with *Ableton Live* visit https://youtu.be/Y4ot3rXgKJU

a better fit for the AirSticks, as the sustain of a synthesised sound can be easily controlled. I did investigate different sustain methods of samples through reverbs, delays and granular synthesis within *Ableton Live* and also began trialing several sustain methods of samples within the new software. However, we soon decided to reduce the sonic palette to just synthesis, not only for the purposes of sustain, but also for morphing sounds.

One of the most invaluable changes made to the earliest versions of *CAMS* was to replace the *Box* triggering system with the *Morph* one. In mid-2014 the mapping for the *Nine Lives Live* performance was the first to treat the playing space as a fluid 'fretless' space, where drum synth sounds continuously morphed from one to another. Later in 2014, in *the Sticks* Dock residency, samples were also morphed in this manner. Unfortunately, this had to be done in a rather clumsy way within *Ableton Live*, essentially triggering eight sounds on with the one strike, then, picturing the playing space as a cube, mixing between the levels of these eight sounds in extreme corners of this cube, each with different xyz position volumes. This created a very pleasing effect. It allowed me to freely mix between the sounds and play 'in between' sounds that I had created. For example, I could play a closed hi-hat in front of me and either mix in an open hi-hat sound by striking higher, mix in a shaker sound by striking to the right, or mix in a kick drum sound by striking closer to my body.

The first synth morphing experiments in *Ableton Live* – where the various parameters of each synth sound were controlled instead of simply the volume of each sound – were made in Native Instrument's *FM8*. One feature of *FM8* is a morph pad. Four synth sounds are placed in opposite corners of the square pad. Moving around this pad, the properties of each sound slowly morph to those around them. I used this as a 2D prototype and added some other parameters on the third axis. Using MIDI's 0-127 sample rate did mean that the morphing wasn't as smooth as it could be.

In the *Sweatbands*, the sustain and morphing systems will work automatically in 3D. The user will place pre-designed synth sounds, or 'pegs,' where they like, and the software will automatically morph between them (see Figure 23 for GUI). In the future we hope to reintroduce the sustaining and morphing of samples in this new software.

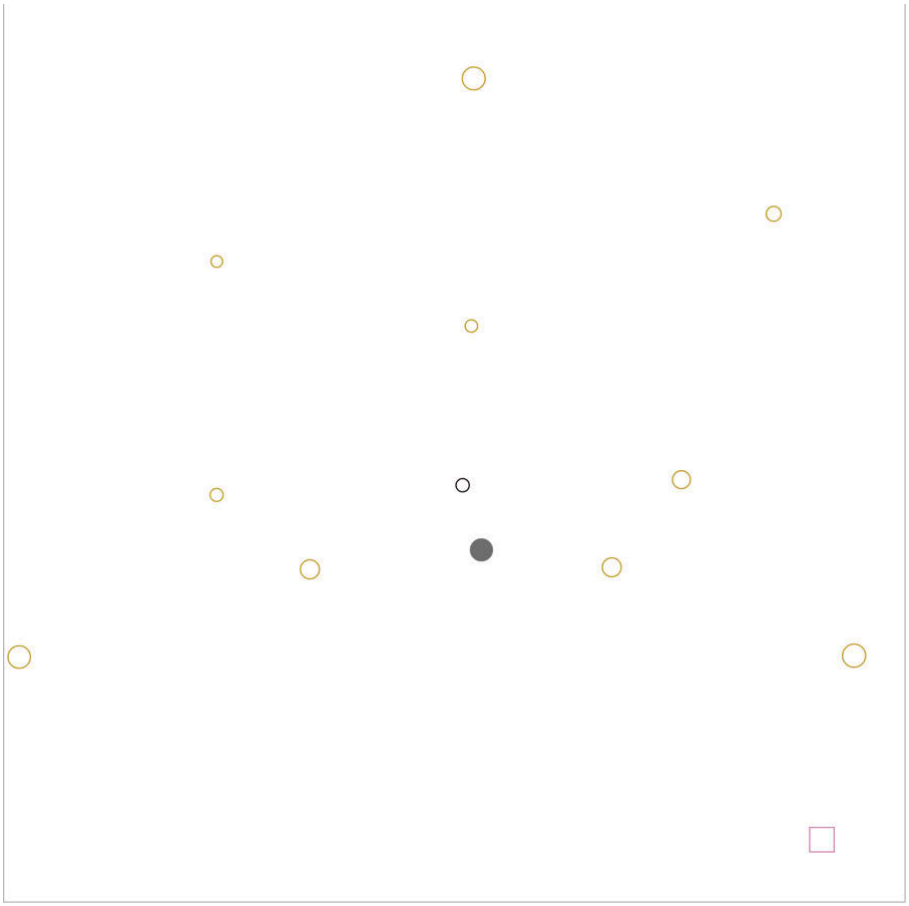


Figure 23. The current Graphical User interface for the new software. Each of these hollow circles or 'pegs' represent a pre-designed synth setting. The filled-in circle is the sound peg which outputs the resulting morphed sound from the synth settings of the neighbouring pegs. This is a 3D representation; the bigger the circle, the closer it is to the performer.

Setting up and Tuning Sounds

Although *CAMS* made the mapping process as fluid as possible with its MIDI Trainer function, making new mappings was always a tedious task. Even in making minor adjustments, the controllers would need to be put down, *CAMS* turned to a different function and various changes made in *Ableton Live* with the mouse. This would hinder the creative flow in rehearsal situations, where others would need to wait. Instead I would often take notes and make the changes later.

In the *Sweatbands*, the controllers themselves will be used to set up and 'tune' sounds. I'm using the word 'tune' instead of mapping because we are trying to make the experience of using the *Sweatbands* feel as much as a conventional instrument as possible. Drummers tune their kits regularly before gigs or recording sessions, adjusting a setup they already know very well. Similarly, the *Sweatbands* will allow the performer to pick a pre-set kit they like, or have created earlier, and quickly adjust it before or during a gig or recording session. Using the controllers to place sounds where desired and change these sounds in an 'edit' mode by moving the other hand would completely free the performer from the keyboard and mouse.

6.2.3 Future Plans for the Sweatbands

The *Sweatbands* are intended to be a more refined version of the AirSticks, specifically for drummers. The refining occurs mostly in the triggering mechanism, the reduction of sonic palette to drum synthesis and greater flexibility within more restricted parameters. We have designed the *Sweatbands* in this way to give them a clearer identity and personality as an instrument, and to lower the entry fee level of the instrument for future *Sweatband* players, opening up the instrument to players with less percussion experience, and allowing drummers to utilise more of their existing motor skills. What may be lost in the design of the *Sweatbands* is the flexibility of mapping options that *CAMS* has given me over this project. We still intend to allow the user access to similar 'open source' features of the instrument, indeed the software will spit out both MIDI and OSC for use by instrument designers who want to map the hardware differently. However, from my research and reflections, I believe that the *Sweatbands* will create a more desirable entry point for drummers than the 'black box' approach with the AirSticks that may paralyse many users. Once they explore the synthesis engine to a certain degree, then they may be inspired to investigate more custom uses of the instrument for their own purposes.

Throughout the AirSticks project I have found particular satisfaction in playing the AirSticks in their most transparent manner – in the role of the drummer. I have also found most unsatisfying the lack of haptic and tactile response, and the inability to translate more expertise from my drumming to the AirSticks. This has led me to often returning to traditional acoustic drums with excitement and relief, a feeling I will elaborate on in the following **Future Projects** section. I often wonder how much a more direct triggering mechanism would maintain my satisfaction on the AirSticks. I have also often wondered about what other functions the AirSticks could have, particularly to people of different skill levels and skill sets. This leads me to the next section on other possibilities for the AirSticks.

6.3 AirSticks 2.0

Throughout this project the focus has been on my own artistic practice, indeed it has been very rare that someone else has even held the AirSticks. In this section I would like to consider the use of the AirSticks beyond my artistic practice, particularly as a controller for interacting and engaging with *Ableton Live* on a deeper level, to enable skill sets such as electronic music composition, sound design, melodic playing and dancing. These are all skill sets that have only been touched upon in this project. I will now briefly discuss some ideas for future software to enable each of these.

6.3.1 Electronic Music Composition

Since I have consistently prioritised the creation of transparent mappings for ensemble playing with the AirSticks, I have given little thought to the use of the AirSticks in electronic music composition. What I am specifically referring to here is the use of open-air controllers in a 'studio' type environment, where the controllers are used to embody the interaction between the composer and the computer, utilising loops, automations and longer audio playback. In this way, the AirSticks player becomes more of a music producer or sound mixer, mixing and fine tuning the music with body movements to speed up the mixing process. This 'minority report' style of futuristic interaction would blur the line between an instrument and a studio tool. When I go to a studio to mix some music with a professional sound engineer, I often get the sense that they are engaging with their computer on such a high level that they are in fact playing it as an instrument. Sound engineers like King Tubby[97] invented whole genres of music from their virtuosity and speed on the mixing desk and other studio tools, creating new pieces of music on the fly from recorded material. This tradition of the live dub or remix is now a staple of live performances, as the studios become more and more portable.

However, engagement with the computer is still often limited to knob turning and fader pushing. Future uses of gestural controllers such as the *Razer Hydras* could amplify these movements made by the producers, not only enabling them more control over more parameters in a shorter time, but also allowing them to create more exciting physical performances, and bring a greater sense of physicality to the sounds.

The relationship between *CAMS* and *Ableton Live* allows much of this kind of interaction – but the design will need refining in order facilitate and encourage use by artists who have more of a background in electronic music production than I do. We hope that with future funding, we can make the AirSticks a staple of any music studio.

6.3.2 Sound Design

Like electronic music producers, sound designers engage with their music making tools for precise control over several parameters. But more than electronic producers, sound designers create beds of sounds that they may need to morph into other beds, taking their listeners

[97] For an example of King Tubby's music visit https://youtu.be/g5jX4hBgDOs

through different scenes of a film or play seamlessly. I have used the AirSticks as a tool for sound design, both in the music making process and for live triggering and manipulation of sound effects in projects that for reasons of space I have not described in detail in this thesis. On all these occasions, the AirSticks were a great tool for telling a story through sound and movement, using simple morphing between prerecorded sound beds. In the live performance of these pieces, I could interact with the performers and watch them intently for cues to bring in the new scene, again blurring the line between the AirSticks being an instrument and simply a tool for manipulating sound.

6.3.3 Melodic Playing

As mentioned briefly in the *AirStorm* case study, the AirSticks have occasionally been used to play melodies. I do not have sufficient training on any tuned instrument, and hence felt out of my depth mapping the instrument for melodic playing short of simple basslines or melodic fragments. I can see though how the AirSticks could be used as a tool for improvising and performing melodies. In a similar fashion to the *Theremin*, pitch on a continuous spectrum can be assigned to movement on one axis and volume to another, leaving several axes free to control other parameters of the sound. A similar triggering method could be used to control the attack, sustain and release of the sound, stretching the movement metaphor of the instrument from striking to bowing. This would allow much more control over timbre than the *Theremin*, and though still difficult to play, any musician used to playing a fretless instrument would be able to 'find' the notes they wish to play. Again, it is fluidity, accuracy and speed that may need to be addressed with the development of new hardware, but I believe that a satisfying melodic mapping could be created on the current version of the AirSticks simply by finding the right instrumentalist to help in the design process.

6.3.4 Dancing

Dancing is an art form that is well beyond my skill set, but the more I performed on the AirSticks, particularly when standing up, the more I got comments that what I was doing was essentially dancing. I have left out two projects with expert dancers that I am currently involved with, though they are included in the Appendixes.[98] During these projects some dancers have explored the AirSticks. The main difficulty in getting the dancers using the AirSticks was the fact that the controllers were wired, and hence the dancer's movements were dramatically limited. With the new hardware design of the *Sweatbands*, and the use of wireless technology, I feel there is a real opportunity to create a new form of performance where dancers closely interact with sound. Also, the development of software to record a dancer's movement to sound and allow them to retrigger and improvise with these sound fragments through similar movements is an exciting prospect for me and an obvious progression from the sound-first mapping approaches taken in "*CF1"* and "*Da Funk*".

[98] See **Appendix D.**

6.4 Future Projects

To conclude this thesis, I would like to quickly include some thoughts on one last project that was not included in the case studies, particularly in its reference to the relationship between my AirSticks, acoustic drum kit and composing practices.

6.4.1 The Hour

"The Hour" is a new immersive audio-visual performance which showcases the AirSticks, my drumming and my composing. I wanted to take a very different approach with this solo piece. I wanted to give the visuals autonomy, treat them like a second performer, personify them and make them play all the impossible mathematical music that I had avoided playing on the AirSticks for the past four years.

The creative process began with the composition of a series of musical movements based around different number sequences that could work on top of each other. I created a rough structure and considered moments where I would play drums or AirSticks over these number sequences. I then invited an animator to take the MIDI note values from these number sequences and visualise them, gathering inspiration from mandalas and tunnel-like images to highlight the phasing that was occurring in the music. We then had use of a performance space for two weeks to create a show from these audio-visual structures, and fill in the gaps with AirSticks and drum features that morphed out of these structures. We wanted to blur the line between the drums and AirSticks by investigating ways of visualising both the drumming and AirSticks playing. With the drumming, it was very clear what sound they were making within the piece, though we did occasionally double the drum sounds with pre-recorded samples. With the AirSticks playing, we wanted to slowly reveal their workings to the audience, in a sense create a narrative for their different uses, and to make clear what was being controlled by the AirSticks and what was part of the 'backing track' and autonomous visuals. We did this by maintaining very different sonic palettes for the AirSticks and the backing track. In the opening, for example, the AirSticks trigger very low synth sounds, which place a blur effect on the visuals, while the backing track is made up of higher tones visualised by mandalas. Later the AirSticks control a low-pass filter of the sound of a rainforest and are visualised by virtual smoke animation which follows my hand positions. The AirSticks are then used to put filter delays over a percussive backing track, moving these delays around a six-speaker array – two front and low, two front and high, and two behind the audience. Moving the sound in this way was extremely satisfying, and expanded on my standard mapping which allowed panning left to right.

The audience was invited to wear 3D glasses so that the computer-generated animations appeared to extend in front of the screen. The movement of the visuals was synched to the spatialisation of the sound, which in turn was synched to my physical movements on the AirSticks. So not only was I able to move the sound in the space with the AirSticks, I was also moving the visuals at the same time.

This synchronicity comes to a head in the show with an AirSticks solo leading into the last musical movement. For the show, I did explore the playing of a melodic fragment, playing a four-note theme in a large square space with my left hand, as can be seen at the start of the video below. My focus throughout the AirSticks moments in the piece was to really use the space, particularly since I had committed to standing centre stage. This led to many comments about the merging of the playing of the AirSticks with dancing, an overlap I will continue to explore further in my practice. I sought movement direction from a choreographer and I drew on this advice in the mapping of the AirSticks, stretching out limbs and enlarging the playing space.

Another direction I received related to gaze – where to look and how to enhance connection with the audience. I had developed a bad habit on the AirSticks where I would look down for a majority of the performance, perhaps due to my early reliance of the graphical interface on the computer screen, or maybe a way to focus my gaze so I wouldn't get distracted. But looking up more in "*the Hour"* really opened up my performance. Also, I explored looking beyond the AirSticks towards where the sound was coming from and also looking more at the controllers, playing with the idea that as a performer I could throw sounds far afield and reel them in at will.

All these elements together took the audience on a one-hour synaesthetic, often meditative and psychedelic journey through sound, physical movement and visuals, exploring our relationship with numbers, spirituality, nature and technology.

The Hour

https://alonilsar.com/thehour

One last point of discussion I'd like to investigate regarding "*the Hour"* is how the AirSticks have changed my relationship with the drum kit, and what elements of my drumming I felt compelled to explore in this piece – elements that I could not come close to exploring on the AirSticks. Throughout this thesis I have stressed that the AirSticks are not a replacement for acoustic drums. They may well replace electronic pads for many situations, especially if we are successful in building the hardware for the new *Sweatbands* version of the AirSticks, but the experience of playing acoustic drums is unique.

Without a doubt, I have had less time to explore the acoustic drums since the emergence of the AirSticks in my artistic practice. The AirSticks, and indeed this PhD, have taken up much of my creative headspace. However, my drumming practice has continued, arguably with more vigour and love for the instrument. Any chance to play is exciting, whether with an orchestra, a rock band, a jazz band or in a free improvisation context. It is within this improvisation context though that I notice the most interaction with my AirSticks practice, a place where my body takes over and my thoughts subside in order to attain a true state of flow.

One noticeable change to my drumming is that I feel a stronger separation between my hands. This may be due to the AirSticks being mapped in a way where both hands cannot trigger the same sound. This separation between my hands has led to the investigation not only of further polyrhythmic playing, but of shifting and morphing rhythms, with one hand speeding up against the other, ever so slightly, until a new rhythm emerges. This is a concept that is much harder to explore on the AirSticks due to the lack of tactile or haptic feedback, and I made sure that I included a morphing drum solo like this in "*the Hour"* and in newer projects like *Ground Patrol*.[99] Much of my current drum practice is a direct reaction to my AirSticks practice, constantly asking myself 'what I can do on the drum kit that I CANNOT do on the AirSticks?'

In "*the Hour"* I also felt that my drumming performance needed to compete with that on the AirSticks. I did not want the magic of the AirSticks performance to overshadow the drumming performance. I approached the four acoustic drum sections in very different ways. One was very quiet and focused on morphing from a visualised 3/4/5 polyrhythm played on two toms and a kick out into a bubbling mess before morphing back into the original visualised rhythm. In another section I focused on playing several different 60 beat cycle grooves – including the 3/4/5 polyrhythm – that were visualised on the kit with projection mapping and MIDI sequenced visuals (this meant my playing had to be perfectly synched to a backing track). The third drumming section involved a very slow speeding up and getting louder of the 3/4/5 polyrhythm again played across two toms and a kick, all synched to a phasing 3D animation inspired by tunnel-like geometry. And lastly, what we called the finale, was a two and half minute complex, loud, playful, intense, non-repetitive, metre-shifting drumming onslaught synched with flashing shapes and colours. None of this drumming could have been done on the AirSticks, and I believed this drumming complimented the use of the AirSticks in the piece. Equally, it could be argued that none of the drumming would have been created

[99] For more info visit http://groundpatrol.net/

without the skills and perspective I gained from playing the AirSticks.

6.5 Conclusion

In this section I have outlined future software and hardware ideas in the development of the AirSticks in my creative practice and beyond, focusing on utilising the motor skills of a drummer further in the hardware development, and the possibilities for engaging with music software more intuitively in the software development for other skill sets. I also outlined my latest audio-visual project which featured my own electronic production, composition and acoustic drumming, creating a neat end to the narrative of my creative practice from the acoustic drums to my current AirSticks practice.

Chapter 7:

Conclusion

7.1 Conclusion

In this thesis, I have presented the developments of a new instrument for the live performance of electronic percussion that has emerged from my creative practice both as a drummer and electronic producer. Contributions to the field of new instrument design and electronic music making in general were peppered throughout the thesis and will be gathered here in this conclusion for convenience.

To set up the narrative of this project, I gave a brief history of my practice and the early prototypes of the instrument that I had created with co-designer Mark Havryliv before the research and design criteria for the AirSticks were formalised. I also gave a more general history of percussion and the emergence of new technology that enables performers to play electronic percussion without hitting a physical drum or pad. A short glossary of terms that are regularly used in the field of instrument design were also outlined.

My aims were very much tied in with the first three research questions:

Question 1
What are some effective ways to utilise the existing motor skills of expert drummers in designing the AirSticks?

Question 2
What are some effective ways to utilise the latest in motion capture technology?

Question 3
What ways are there to facilitate more satisfying collaborations between artists across different artforms without technology hindering the creative process?

These questions were not only addressed through this written thesis, but also through the actual design of the instrument and the creative output of using the instrument in the music making process, from improvising, rehearsing, arranging, remixing, composing, performing and recording on the AirSticks. The instrument itself and the creative output are major contributions to this research project. Hence some of the technical discoveries of creating the instrument were included in this thesis, particularly elements that address some of the effective ways to utilise the latest in motion capture technology. One of these technical discoveries, our triggering system, was outlined in this thesis, and discussed in respect to how it allowed us to also control velocity, sustain and release of sounds through the data sent from the *Razer Hydra* gaming controllers. Several documented performances on the AirSticks were also linked to in this thesis to emphasise the role of the creative output in the project's overall contribution to knowledge.

Upon further investigation into the field of new instrument design in attempting to address these first three questions in the thesis, a fourth and main research question emerged:

Question 4

What are some effective ways of overcoming creative paralysis in tackling the mapping problem?

My method in addressing these questions was through a self-reflective, artistic, practice-based approach, justified here within the Methodology chapter. One insight gained from justifying this method was the slight variations on reflecting-in-action that occur within improvisation and their impact on the instrument design process. A contribution gathered from this part of the project is for new instrument designers to be aware of whether they are fully present and focused on improvising or whether they are still in 'design' mode, questioning the constraints of the instrument instead of playing within them.

My approach throughout this project was to find myself in as many different creative projects as possible in order to regularly push the use of the AirSticks into unchartered waters. Through a series of case studies, I presented an insight into the process of using the AirSticks in my creative practice in all these different musical situations, from solo to ensemble playing, with musicians, dancers and visual artists. I focused, for the purposes of this thesis, on the playing of untuned percussion mappings, but also explored the live manipulation of other instruments, the playing of melodies, the triggering of visuals and the interaction between music performance and dance.

The bulk of the contribution of this written thesis came from reflecting upon these case studies in the Discussion chapter, suggesting some effective ways of overcoming creative paralysis in tackling the mapping problem. I outlined four main mapping approaches that had emerged from my case studies that could help overcome this paralysis. These were:

- sound-first mapping,
- movement-first mapping,
- genre-specific mapping, and
- mapping for an ensemble.

All these approaches invite the instrument designer to begin their mapping process with a specific creative output in mind, be it a sound (whether a loop, collection of samples, sound world or completed piece), movement (a strike, or turn, or growing of a movement over time) or a genre. The designer must then also be open to this output shifting, particularly as collaborators bring in their ideas into a project, helping to facilitate more satisfying collaborations between artists across different artforms. A major case laid out in this thesis is indeed that more attention needs to be paid to designing instruments for playing within ensembles, both to help in the design process and promote the field of instrument design.

From reflecting on the projects presented in this thesis, I gained knowledge on which approaches were satisfying for me and the collaborators, and which were not. I also began to label and identify these different approaches, from which deeper concepts emerged. Many of these concepts have been explored by other instrument designers to varying degrees. Mapping by metaphor, for example, has been written about in great detail by several researchers,

particularly in regards to using the playing of acoustic instruments as movement metaphors for new instruments. In the AirSticks' case, the mapping is grounded in the playing of percussion movement metaphor, and hence was one of the effective ways to help utilise the skills of an expert drummer in learning the instrument.

One concept which is a new contribution in this thesis is the use of magic and illusion in mapping. I presented magic and illusion in mapping as a way to play with the audience's idea of what is 'real,' utilising the decoupling of movement and sound in DMIs to investigate playing with the inherent disembodiment of sound, physicalising sound, and subverting realness.

Lastly, I outlined future software and hardware possibilities and my latest projects including a solo performance called "*the Hour"* which was a culmination of many of the concepts discussed throughout this written thesis.

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Appendix A

List of Figures

Appendix B

Glossary of Terms

- **Ableton Live** – A digital audio workstation for music production, creation and performance.
- **ADSR –** the attack, decay, sustain and release envelope of a sound
- **Box mapping –** A function in the early CAMs that allowed the triggering of 16 discrete MIDI note values
- **CAMs –** Custom AirSticks MIDI software, programmed by Mark Havryliv, design by Alon Ilsar and Mark Havryliv to read data from the Razer Hydra gaming controllers and convert it into MIDI note values and control changes
- **Chopper –** An effect in Ableton Live that allows the cut up of a sustained note into a pulse
- **Frequency Modulation (FM) synthesis –** The use of signal processing to create complex sound through modulating the frequency of a waveform
- **Granular synthesis –** The use of signal processing to convert tiny artefacts of a sample into new tones and sounds
- **GUI –** Graphical User Interface
- **LFOs –** Low Frequency Oscillators, is a slow signal pulse, often used to change another parameter of sound
- **MIDI Trainer function –** A function built into CAMs to allow the user to more easily map the movements of the AirSticks into different MIDI note values and control changes.
- **Morph mapping –** A function introduced into CAMs to allow the triggering of a Single Global MIDI note, which in turn allowed the programming of continuous morphing of sound through changing parameters in Ableton Live
- **Template mapping –** The mapping used at the beginning of a project from which the new mapping is built from
- **Untuned Percussion –** Any acoustic or electronic percussion instrument with no defined pitch or ability to play even simple melodies

Appendix C

List of Public Performances on the AirSticks

Below is a thorough list of all the public performances and presentations done on the AirSticks. The date, name of the event (if applicable), location, ensemble name and the name of the piece are included. Where available, a link to documentation of the vent is also provided.

5/3/2013 ***Lamps, Surry Hills, Sydney, AUS***
Solo improvisation at Dorkbot
https://youtu.be/kUkmLtq6C-c
https://youtu.be/SBsOPnTgr-c

13/3/2013 ***ArtSpace, Woolloomooloo, Sydney AUS***
Solo performance of "*Air Vacuum*" at CCS Presentation Night

7/5/2013 ***107 Projects, Redfern, Sydney, AUS***
Faulkland, "*Robotross and Puffin"*at Jazzgroove

23/5/2013 ***Bon Marche, UTS, Ultimo, Sydney, AUS***
Solo structured improvisation at Diffuse

8/62013 ***Lamps, Surry Hills, Sydney, AUS***
Improvised duo with Sanna supporting Wires

13/6/2013 ***Bon Marche, UTS, Ultimo, Sydney, AUS***
Solo performance of "*Air Vacuum*" at ISEA2013
https://youtu.be/zD0gQMCvP68

19/6/2013 ***Eugene Goosens Hall, Ultimo, Sydney, AUS***
Solo performance of "*Air Vacuum*" at 9th ACM Conference on Creativity and Cognition
https://youtu.be/OvT02BuBvDM

7/10/2013 ***Amsterdam, NED***
Improvisation with quartet at Oosprong

5/11/2013 ***Hanut31, Tel Aviv, ISR***
Improvised duo with Masel at the Hanut 31 Series

21/11/2013 ***The Red Door, New York City, USA***
Duo with Coleman "*Drum Vacuum One*" & quintet improvisation at Hyphen Hub's Digital Salon

22/11/2013 ***Fridman Gallery, New York City, USA***
Duo with Sanna "*Dark As A Dungeon*" at Fridman Gallery Session

7/12/2013 ***Lancaster, USA***
Improvised duo with Motzer & visual artist at 1k Sessions

8/12/2013 ***Mount Vernon Dance Space, Philadelphia, USA***
Duo with Motzer & dancers at Monday Night Improv Showing

12/12/2013 ***The Red Door, New York City, USA***
Solo with visuals "*H2.0*" & duo with Sanna "*Dark As A Dungeon*" at Hyphen Hub's Digital Salon
https://vimeo.com/83406035

9/1/2014 ***The Red Rattler, Marrickville, Sydney, AUS***
Splinter Orchestra improvisation at the NOW now

28/2/2014 ***MCA, Sydney, AUS***
Malarkey with LCC "*TMT: Five pieces*" at Jam-arrama, ArtBar

13/3/2014 ***Austin, USA***
Malarkey with LCC "*TMT: Five pieces*" at SXSW

21/3/2014 ***The Red Door, New York City, USA***
Malarkey with LCC "*TMT: Five pieces*" at Hyphen Hub's Digital Salon

30/3/2014 ***107 Projects, Redfern, Sydney, AUS***
Cursar structured improvisation at Pretty Gritty

4/6/2014 ***London, UK***
Silent Spring "Dawn" at NIME14

24/7/2014 ***The Basement, Sydney, AUS***
Silent Spring "*Dawn*" & *Malarkey* original set supporting Facemeat
https://youtu.be/M8rF0pbbpqY
https://youtu.be/Eo28f_f9Rrc

21//8/2014 ***CCS, UTS, Ultimo, Sydney, AUS***
Solo "*Nine Lives Lives*" at CCS Concert Series
https://youtu.be/_4d1nRrPV9U

30/8/2014 ***Herman's Bar, Sydney, AUS***
Brian Campeau originals at NiceFest

7/10/2014 ***Foundry 616, Ultimo, Sydney, AUS***
Structured improvisation with Kirkwood at Jazzgroove

4/11/2014 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Curwin at The Sticks Residency

11/11/2014 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Rapaport at The Sticks Residency

18/11/2014 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Havryliv at The Sticks Residency

25/11/2014 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Miller at The Sticks Residency

28/11/2014 ***The Annandale Hotel, Sydney, AUS***
Facemeat originals

29/11/2014 ***Lake Mountain Alpine Resort, Victoria, AUS***
Kirin J Callinan originals at Paradise Music Festival

2/12/2014 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Dubber at The Sticks Residency

9/12/2014 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Ferenci at The Sticks Residency

16/12/2014 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Morphingaz at The Sticks Residency

19/12/2014 ***Marlborough Hotel, Newtown, Sydney, AUS***
Improvisation with *The Sticks* at Sing sing

23/12/2014 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Sutherland at The Sticks Residency

2/1/2015 ***The Annandale Hotel, Sydney, AUS***
Improvisation with *The Sticks* duo supporting Fat Yahooza

6/1/2015 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Panucci at The Sticks Residency

13/1/2015 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Hollo at The Sticks Residency

20/1/2015 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Head at The Sticks Residency

15/1/2015 ***Spiegeltent, Sydney, AUS***
Kirin J Callinan originals at Sydney Festival

24/1/2015 ***Melbourne, AUS***
Kirin J Callinan originals at Sugar Mountain Festival

27/1/2015 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Bruce/Goodman at The Sticks Residency

29/1/2015 ***Belvoir Theatre, Surry Hills, Sydney, AUS***
Solo with actors of original score *Bondi Dreaming*
https://youtu.be/BXia-nYcigQ

30/1/2015 ***Belvoir Theatre, Surry Hills, Sydney, AUS***
Solo with actors of original score *Bondi Dreaming*

31/1/2015 ***Belvoir Theatre, Surry Hills, Sydney, AUS***
Solo with actors of original score *Bondi Dreaming*

1/2/15 ***Belvoir Theatre, Surry Hills, Sydney, AUS***
Solo with actors of original score *Bondi Dreaming*

2/2/15 ***Belvoir Theatre, Surry Hills, Sydney, AUS***
Solo with actors of original score *Bondi Dreaming*

3/2/15 ***Belvoir Theatre, Surry Hills, Sydney, AUS***
Solo with actors of original score *Bondi Dreaming*

4/2/15 ***Belvoir Theatre, Surry Hills, Sydney, AUS***
Solo with actors of original score *Bondi Dreaming*

10/2/2015 ***Foundry 616, Ultimo, Sydney, AUS***
The Sticks improvisation at Jazzgroove
https://youtu.be/q42oNLO2frk

2/28/2015 ***Brownlow Hill, AUS***
The Sticks improvisation at Secret Gardens Festival

2/3/2015 ***The Red Rattler, Marrickville, Sydney, AUS***
Solo structured improvisation

12/3/2015 ***The Dock, Redfern, Sydney, AUS***
Glitch Jukebox improvisation

13/3/2015 ***Jam Gallery, Bondi, Sydney, AUS***
The Sticks improvisation at Jaws

25/3/2015 ***Venue 505, Surry Hills, Sydney, AUS***
The Sticks improvisation supporting Gavin Ahearn

26/3/2015 ***The Dock, Redfern, Sydney, AUS***
Glitch Jukebox improvisation

16/4/2015 ***Lamps, Surry Hills, Sydney, AUS***
The Sticks "*Visualised*" with Andrew Bluff and Andrew Johnston
https://vimeo.com/126761815

24/4/2015 ***Alpha House, Erskenville, Sydney, AUS***
Solo structured improvisation at Alpha Waves

30/4/2015 ***Surry Hills, Sydney, AUS***
Brian Campeau originals at High Tea

1/05/2015 ***Canberra, AUS***
The Sticks duo "*Visualised*" with Bluff/Johnston at the Canberra International Music Festival

2/05/2015 ***Canberra, AUS***
The Sticks duo "*Visualised*" with Bluff/Johnston at the Canberra International Music Festival

3/05/2015 ***Canberra, AUS***
The Sticks duo "*Visualised*" with Bluff/Johnston at the Canberra International Music Festival

10/5/2015 ***Django Bar, Marrickville, Sydney, AUS***
Brian Campeau originals at the Brian Campeau Album Launch

21/5/2015 ***Sydney Opera House, Sydney, AUS***
The Sticks "*World Maps*" at TedxSydney
https://youtu.be/WbtQ9zKkhyc

29/5/2015 ***Seymour Centre, Sydney, AUS***
Improvised duo with guitar pinball machine at Vivid: Musicify and Gamify
https://www.dropbox.com/sh/c5hc47o5gvc64dh/AAC_JmIPJ7ZV-AFWj752HMXza/Concert%201%20-%20Alon%20Ilsar-HD%20720p.mov?dl=0

29/5/2015 ***Lamps, Surry Hills, Sydney, AUS***
The Sticks improvisation

31/5/2015 ***Lansdowne, Sydney, AUS***
The Sticks improvisation

2/6/2015 ***Evelyn Hotel, Melbourne, AUS***
The Sticks originals at AO

4/6/2015 ***Hugs and Kisses, Melbourne, AUS***
The Sticks originals at the Melbourne Internation Jazz Festival

5/6/2015 ***Golden Monkey, Melbourne, AUS***
The Sticks originals at the Melbourne Internation Jazz Festival

6/6/2015 ***Retreat Hotel, Melbourne, AUS***
The Sticks originals

11/6/2015 ***The Red Rattler, Marrickville, Sydney, AUS***
The Sticks "*Visualised*" with Bluff/Johnston
https://vimeo.com/132565629 pass: rattler

24/6/2015 ***Glasgow, UK***
"*AirStorm*" with Bluff at 10th ACM Conference on Creativity and Cognition

10/7/2015 ***ZKM, Karlsruhe, GER***
"*AirStorm*" with Bluff at the ZKM AppArtAwar
http://zkm.de/en/media/video/appartaward-2015

23/7/2015 ***Greenhouse, Berlin, GER***
The Sticks improvisation

3/9/2015 ***Platform, Glasgow, SCO***
Kind of Silence show for deaf and hearing audiences

6/9/2015 ***One Touch Theatre, Dean Court, SCO***
Kind of Silence show for deaf and hearing audiences

8/9/2015 ***Gordonstoun, Elgin, SCO***
Kind of Silence show for deaf and hearing audiences

13/9/2015 ***Lemon Tree, Aberdeen, SCO***
Kind of Silence show for deaf and hearing audiences

18/9/2015 ***Gaiety Theatre, Ayr, SCO***
Kind of Silence show for deaf and hearing audiences

19/9/2015 ***Beacon Theatre, Glenock, SCO***
Kind of Silence show for deaf and hearing audiences

7/10/2015 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Rodriguez at The Sticks Residency

9/10/2015 ***Mr Falcon's, Glebe, Sydney, AUS***
The Sticks duo improvisation

14/10/2015 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Botting at The Sticks Residency

20/10/2015 ***Foundry 616, Ultimo, Sydney, AUS***
Sega Ros "*Themes from Sonic the Hedgehog*" at Jazzgroove

21/10/2015 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Meredith at The Sticks Residency

28/10/2015 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Farrar at The Sticks Residency

4/11/2015 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Bown at The Sticks Residency

6/11/2015 ***Mr Falcon's, Glebe, Sydney, AUS***
The Sticks duo improvisation

10/11/2015 ***Foundry 616, Ultimo, Sydney, AUS***
Structured improvisation with Evans & Kirkwood's Mieville Project at Jazzgroove
https://youtu.be/3gn_m4dzLXs

11/11/2015 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Keegan at The Sticks Residency

13/11/2015 ***The Red Rattler, Marrickville, Sydney, AUS***
The Sticks with Campeau/Stone originals supporting Baz

26/11/2015 ***Surry Hills, Sydney, AUS***
The Sticks originals at High Tea

30/11/2015 ***UTS, Ultimo, Sydney, AUS***
"*AirStorm*" with Bluff at the Storytelling Conference

3/12/2015 ***Freda's, Chippendale, Sdyeny, AUS***
The Sticks originals at The Sticks Album Launch Party

6/12/2015 ***Cross St, Melbourne, AUS***
The Sticks "*Visualised*" with Bluff/Johnston

8/12/2015 ***Bar Open, Melbourne, AUS***
Improvisation with Simmons at the Make It Up Club

10/12/2015 ***The Sly Fox, Enmore, Sydney, AUS***
The Sticks improvisation supporting the New Venusians

19/12/2015 ***The Bald Faced Stag, Leichhardt, Sydney, AUS***
The Sticks duo improvisation supporting Anklepants

13/1/2016 ***Venue 505, Surry Hills, Sydney, AUS***
Structured improvisation with Evans supporting Bambino

15/1/2016 ***Foundry 616, Ultimo, Sydney, AUS***
The Sticks with Hauptman improvisation at Jazzgroove Festival

16/1/2016 ***APRA, Ultimo, Sydney, AUS***
Solo Masterclass

23/1/2016 ***Venue 505, Surry Hills, Sydney, AUS***
Kirkwood's Mieville Project

28/1/2016 ***The Red Rattler, Marrickville, Sydney, AUS***
The Sticks "*Visualised*" with Bluff/Johnston
https://youtu.be/GLbbWzlhMVc

26/3/2016 ***Firehouse, Brooklyn NYC, USA***
Duo with Sheldon

2/4/2016 ***Brookyln College, NYC, USA***
Presentation at the PIMA Symposium

6/5/2016 ***Clemente Soto Velez Center, NYC, USA***
Presentation at Creative Tech Week

6/5/2016 ***Clemente Soto Velez Center, NYC, USA***
"AirStorm" with Bluff at Creative Tech Week

7/5/2016 ***Clemente Soto Velez Center, NYC, USA***
Velize at Creative Tech Week

7/5/2016 ***Rockwood Music Hall, NYC, USA***
Improvisation with Sanna and Austin

10/6/2016 ***Kraine Theatre, NYC, USA***
"CF1"

26/6/2016 ***National Sawdust, Brooklyn, NYC, USA***
Aether with Aether dancers

26/6/2016 ***Church of the Friendly Ghost, Austin, USA***
Cephalon improvisation at New Media Arts and Sound Summit

27/6/2016 ***Church of the Friendly Ghost, Austin, USA***
Velize improvisation at New Media Arts and Sound Summit

29/6/2016 ***Stay Gold, Austin, USA***
Velize improvisation

7/9/2016 ***Rockwood Music Hall, NYC, USA***
Skye Steele originals

2/10/2016 ***Rockwood Music Hall, NYC, USA***
Skye Steele originals

23/10/2016 ***Rockwood Music Hall, NYC, USA***
Skye Steele originals

13/11/2016 ***Shapeshifter, Brooklyn, NYC, USA***
Velize with Grubbs

17/11/2016 ***Liberty Science Centre, Jersey, USA***
"Aether" with the Aether dancers at Sunday Firsts

10/12/2016 ***The MET Museum, NYC, USA***
"Max and Alan" by Alan Cumming

20/12/2016 ***Happy Lucky Gallery, Brooklyn, NYC, USA***
Various works on AirSticks
https://youtu.be/ZVqDkmFw7w8
https://youtu.be/8OXm85icbmg
https://youtu.be/LluVrSOBzuk
https://youtu.be/8aqup3SDJ9k
https://youtu.be/97ALntmIKT0

6/1/2017 ***Spectrum, NYC, USA***
Monotreme improvisation
https://youtu.be/3KvFPKnFFHc
https://youtu.be/CqWqJAs4fXE
https://youtu.be/BcncAGqxIws

10/1/2017 ***Kraine Theatre, NYC, USA***
"Voyager" with Neshamah Dancers
https://youtu.be/Sx8WmOzv3Lo?t

12/1/2017 ***Rockwood Music Hall, NYC, USA***
Group improvisation

16/1/2017 ***Space, Brooklyn, NYC, USA***
Improvisation *with* Harmet

4/2/2017 ***Foundry 616, Ultimo, Sydney, AUS***
Structured improvisation with Evans at SIMA

26/2/2017 ***Campbelltown Art Centre, Campbelltown, Sydney, AUS***
"The Hour"
https://youtu.be/ibZoayB_xuk

31/2/2017 ***Conservatorium of Music, Sydney, AUS***
Presentation for Contemporary Music Class

7/3/2017 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Ferenci at The Sticks Residency

14/3/2017 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Farrar at The Sticks Residency

21/3/2017 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Martyn at The Sticks Residency

25/3/2017 ***107 Projects, Redfern, Sydney, AUS***
Structured improvisation with Saunders (dancer) at Contemporary Contemporary Contemporary

28/3/2017 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Thomas at The Sticks Residency

4/4/2017 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Mannell at The Sticks Residency

8/4/2017 ***Giant Dwarf, Redfern, Sydney, AUS***
The Sticks at duo Sketch The Rhyme

10/4/2017 ***The Enmore Theatre, Enmore, Sydney, AUS***
The Sticks originals supporting Snarky Puppy

11/4/2017 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Tully/Inês at The Sticks Residency

15/4/2017 ***Golden Age, Surry Hills, Sydney, AUS***
The Sticks originals

18/4/2017 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Barker at The Sticks Residency

4/5/2017 ***Rockwood Music Hall, NYC, USA***
Improvisation with Koenig

14/5/2017 ***Pioneerworks, Brooklyn, NYC, USA***
"Aether" with the Aether dancers at Sunday Firsts

20/5/2017 ***Five Myles Gallery, Brooklyn, NYC, USA***
Improvisation with Sanna at Creative Tech Week

22/5/2017 ***Shapeshifter, Brooklyn, NYC, USA***
"Voyager" with Neshamah Dancers

2/6/2017 ***The National Mall, Washington DC, USA***
"Voyager" with Neshamah Dancers at the Astromony Festival

7/6/2017 ***Conservatorium of Music, Sydney, AUS***
Presentation for Contemporary Music Class

10/6/2017 ***Conservatorium of Music, Sydney, AUS***
"The Hour" at Vivid at the Con

3/7/2017 ***107 Projects, Redfern, Sydney, AUS***
Presentation at Hack Sounds
http://www.hacksounds.com/2017/07/airsticks-with-alon.html

11/7/2017 ***107 Projects, Redfern, Sydney, AUS***
Improvised solo at the NOW now

15/7/2017 ***Foundry 616, Ultimo, Sydney, AUS***
Sandy Evans Sextet at Rockpools CD Launch

23/7/2017 ***North Byron, AUS***
Thundamentals at Splendour in the Grass

29/7/2017 ***Giant Dwarf, Redfern, Sydney, AUS***
The Sticks at duo Sketch The Rhyme

23/8/2017 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Ferraro at The Sticks Residency

31/8/2017 ***The Dock, Redfern, Sydney, AUS***
Improvisation with *The Sticks* & Ryan/Inês at The Sticks Residency

Appendix D

Other Recent Projects Worth Noting

Aether (5/2016 -)

Aether is a one-hour piece based around the four classic elements and sacred geometry. It is a collaboration between composer Darren Solomon, dancer and computer programmer Kat Robinson, and me on sound design and the AirSticks.

In the work-in-progress showing in June 2016, three dancers wore motion capture suits that allowed the projection of their figures (or avatars) onto a screen. These avatars were programmed, at different moments in the piece, to represent the four elements; earth, water, air, fire. The choreography was inspired by each of these elements, as was the composition and sound design. All the samples I used on the AirSticks in *Aether* were of these elements.

One highlight of the show is the interaction between the performance on the AirSticks and the dancer in the section inspired by water (see video link below). It is this kind of physical interaction that we are hoping to build on further in our next development. We are also hoping to expand the custom software so that the dancers can influence the sound, and that I can influence the visuals. I will also be wearing the motion capture suit to further blur the line between the musicians and dancers.

Aether by Aether dancers, Darren Solomon and Alon Ilsar (26/6/16)
https://youtu.be/sMJjZ8yltfA

Voyager (7/2016 -)

Voyager is a dance show influenced by Carl Sagan's book 'Cosmos', performing the narrative of NASA's Voyager I and II. This collaboration between choreographer Hannah Cohen of Neshamah Dance Company and me grew out of working on the first choreographed piece for the AirSticks, "*CF1*." Inspired by this initial collaboration, Hannah set up to audition 45 dancers in New York to create a small ensemble piece based around my movements on the AirSticks. Themes of connectivity, longing, communication and loss were all explored through these interactions, with the dancers often mimicking my movements, but also physically moving my body to create sound (see video link below).

In having dancers mimic and extend my current gestures on the AirSticks, and impart me with knowledge on new ways to move with the gestural instrument, all while exploring the inspiring narrative of space exploration, the show has contributed further to my AirSticks practice.

Voyager by Neshamah Dancers, Hannah Cohen and Alon Ilsar (10/1/17)
https://youtu.be/Sx8WmOzv3Lo?t=7m15s

Appendix E

List of Publications

Ilsar, A., & Fairchild, C. 2016, 'We are, the Colors: Collaborative narration and the experimental construction of a non-existent band', in S. Whiteley & S. Rambarran (eds.), *Music and Virtuality,* Oxford University Press, New York, NY, pp. 234-45.

Ilsar, A. & Johnston, A. 2015, 'Choreography in the mapping of new instruments', *Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition*, *Glasgow, UK, June 22-25 2015*, pp. 161-4.

Ilsar, A. & Bluff, A. 2015, "AirStorm,'A New Piece for AirSticks and Storm: Gestural Audio-Visual for Electronic Percussionists', *Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition*, *Glasgow, UK, June 22-25 2015*, pp. 389-90.

Ilsar, A., Havryliv, M. & Johnston, A. 2014, 'Evaluating the performance of a new gestural instrument within an ensemble', *Proceedings of 14th International Conference on New Interfaces for Musical Expression, London, UK, June 30 - July 4 2014,* pp. 339-42.

Ilsar, A., Havryliv, M. & Johnston, A. 2013, 'The AirSticks: A new interface for electronic percussionists', *Proceedings of the 2013 Sound and Music Computing Conference, Stockholm, Sweden, 30 July - 3 August 2013,* pp. 220-6.

Appendix F

List of Recordings

Sandy Evans - *RockPoolMirror*
Released July 15, 2017 on Tall Poppy Records
Available at http://www.tallpoppies.net/

Silamor - *Overtures (feat. Benny Smith and Alon Ilsar)*
released independently on March 8, 2016
Available at https://silamor.bandcamp.com/track/overtures-feat-benny-smith-and-alon-ilsar

The Sticks - *The Sticks*
released November 6, 2015 on Broken Stone Records
Available at https://thesticksband.bandcamp.com/releases

Velize – *Velize*
released independently on May 17, 2016
Available at https://velize.bandcamp.com/album/velize

Velize - *Chance-Imagery*
released independently November 12, 2016
Available at https://velize.bandcamp.com/album/chance-imagery

Velize *Extravegetal Arms*
released independently on July 12, 2017
Available at https://velize.bandcamp.com/album/extravegetal-arms

Appendix G

List of Work Specific to Film

***"AirSticks Documentary"* by Adam Rosenberg feat. Alon Ilsar and Bronwyn Cumbo (5/8/14)**
Recorded, mixed and mastered by Alon Ilsar
Filmed and edited by Adam Rosenberg
https://vimeo.com/102674835

"*AirStorm Improvisation 1*" by Alon Ilsar & Andrew Bluff (5/3/15)
Recorded, mixed and mastered by Alon Ilsar
Filmed by Andrew Bluff
https://youtu.be/UsPtnSEwYEY

Alon Ilsar's AirSticks on ABC's The Mix
https://youtu.be/Z0TpXUexqpI

***"Anthem for the Earnest" (The Bad Plus)* by *the Sticks* (19/1/16)**
Recorded, mixed and mastered by Jono Holmes
Produced by Wedge Tail Productions
https://youtu.be/84CFdukpr-U

***"Big Jet Plane"* by *Tuka* feat. Alon Ilsar (5/11/15)**
Produced by Triple J
https://youtu.be/7udwea5-psY

"*Building Steam" (DJ Shadow)/ "Aquarius" (Boards of Canada)* by *the Sticks* (19/1/16)
Recorded, mixed and mastered by Jono Holmes
Produced by Wedge Tail Productions
https://youtu.be/ADVomKdKbpY

"*Crosshairs" (Dangerdoom*) by *the Sticks* feat. *Rapaport* (19/1/16)
Recorded, mixed and mastered by Jono Holmes
Produced by Wedge Tail Productions
https://youtu.be/ISjOUIMv8mI

***"Da Funk" (Daft Punk)* AirSticks by Alon Ilsar (11/7/16)**
Recorded, mixed and mastered by Alon Ilsar
Filmed by Alon Ilsar
https://youtu.be/8fAmdGLrgvA

"*Drum Vacuum One (Amsterdam)*" by Alon Ilsar & Gerri Jäger (11/10/13)
Recorded, mixed and mastered by Alon Ilsar
Filmed and edited by Ellenoor Bakker
https://youtu.be/8uBD5bu_dEc

"*Indian Deli" (Madlib*) by *the Sticks* (19/1/16)
Recorded, mixed and mastered by Jono Holmes
Produced by Wedge Tail Productions
https://youtu.be/sG1ebL1G33s

"*My Star*" by Tuka feat. Alon Ilsar (5/11/15)
Produced by Triple J
https://youtu.be/e3OE-q6OC8c?t=2m32s

"*Overture*" by *Silamor feat. Alon Ilsar* (28/3/16)
Recorded, mixed and mastered by Ben Romalis
Filmed and edited by Ben Romalis
https://vimeo.com/160675268

"*Robotross Part 1*" by *Faulkland* (14/5/13)
Recorded. mixed and mastered by Alon Ilsar
Filmed by Alon Ilsar
https://youtu.be/tUuTJH1pvjU

"*See*" by *Malarkey* & *LCC* (21/3/14)
Recorded, mixed and mastered by Alon Ilsar
Filmed and edited by Mark Bolotin
https://vimeo.com/103199272

"*She Moves She" (Four Tet*) by *the Sticks* (19/1/16)
Recorded, mixed and mastered by Jono Holmes
Produced by Wedge Tail Productions
https://youtu.be/UGjKUockJJ8

"*Shug*" by *the Sticks* (22/12/14)
Mixed and mastered by Jono Holmes
Recorded and filmed by Matthew Stuart
https://vimeo.com/115219681

"*Sidestep*" by *the Sticks* feat. Jane Sheldon (Recorded 12-16/2/15)
Recorded. mixed and mastered by Jono Holmes
Produced by Wedge Tail Productions
https://youtu.be/SnpTFW-6804

"*So It Goes*" by *Malarkey* & *LCC* (21/3/14)
Recorded. mixed and mastered by Alon Ilsar
Filmed and edited by Mark Bolotin
https://vimeo.com/101525660

"*Suriol*" by *the Sticks* (22/12/14)
Mixed and mastered by Jono Holmes
Recorded and filmed by Matthew Stuart
https://vimeo.com/115950043

"*Wishes*" (*Beach House*) by *the Sticks* feat. Elana Stone (19/1/16)
Recorded. mixed and mastered by Jono Holmes
Produced by Wedge Tail Productions
https://youtu.be/szQ_xabhq_k

"*World Maps*" by *the Sticks* (Recorded 12-16/2/15)
Recorded. mixed and mastered by Jono Holmes
Produced by Wedge Tail Productions
https://youtu.be/J1mr472SOdw

For more videos visit
https://alonilsar.com/