The Liberation of the Feet: Computer Enhanced Footwear for Theatrical Audiovisual Expression

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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.

Alexandra Murray-Leslie

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Throughout the first year of my research, SymbioticA's Oron Catts and Assoc. Prof. Jonas Rubensons' support was invaluable, I will always remember my early conversation with Prof. Andrew Belser at ADRI, Penn State about the feet and writings of Tim Ingold, which changed the course of my research.

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This research also builds on my first shoe collaboration with my dear friend Max Kibardin, a real shoe maker by profession, who shared so much of his art of shoe making and fashion style. Many of the works in this thesis grew from our initial collaborations such as the E-Shoe in the artists background section of Chapter 2. The heels I retro engineered were based on his original designs at Bruno Magli, these are discussed in depth in Chapter 4.

Thank you to my family for supporting me in so many ways throughout this journey: Mum, Dad, Monique, Sarah, Tim, Alex, Gabriella, Roberto, Bruno, Camilla, Valeria, Nico and Leon.

I dedicate this thesis to my mother and husband

Abstract

Building upon my established history as a performance artist and pop musician, this research investigates new ways of costuming the foot for theatrical audiovisual expression as a 'gesamtkunstwerk'—an all-embracing artwork that adopts and makes use of many artforms and disciplines.

Through the development of a series of *Computer Enhanced Footwear* (*CEF*) prototypes, this research demonstrates how this gesamtkunstwerk came together through the intersection of fashionable costume design, pop music, dance choreography, lens-based work, scenography, kinesiology, sound and lighting system design and 3D fabrication practices. Resulting in a unified body of work, grounded by the notion that shoes and feet are more than simply tools to help carry our bodies around. They can be reimagined through the act of performance and the application of audiovisual technology to make a statement, semantically communicate social-political concerns and facilitate free, spontaneous expression.

Explorations of philosophical concepts around the feet and footwear from anthropology, natural science and medical literature are featured in this research, along with examples and descriptions of foot-based designs related to prosthetics, fashion, pop music, and performance art to illustrate the vast potentials for the feet as instruments, costumes and more.

Detailed portrayals of my personal art method are presented to showcase my cross-disciplinary, reflexive and experimental practice-based approach, which occurred within varied contexts and settings, including fabrication workshops, sports science laboratories, pole dance studios, music festival stages, fashion catwalks and art museum events. As well as illustrate how these divergent practices converged during the research, to create the *CEF* prototypes and shape their materials, functions and aesthetics, in an effort to liberate the feet when in the air, on the ground or submerged in water.

Analysis and self-reflections of the researcher's role as performer and fabricator are provided together with video and photographic documentation to help demonstrate the outcomes and processes of the various *CEF* projects. This includes recounting the insights

which directed theoretical, physical and metaphysical development of past and future *CEF* iterations, as well present a framework outlining the different aspects to consider when prototyping instruments such as *CEF*.

This research also documents more than two hundred performative situations that developed out of the process of developing and testing the *CEF*. These include live solo performances, group performances with my music band Chicks on Speed, as well as studio workshops and performances with collaborating musicians, scientists, pole dancers, choreographers and performance artists. As well as other unexpected outcomes and future project directions that organically evolved out of the research—all of which culminate to guide, influence and form this research gesamtkunstwerk.

Contents

Chapter 1: Introduction

1.1 Introduction

This thesis documents the developments of a series of foot-based audiovisual prototypes, *Computer Enhanced Footwear* (*CEF*), which are designed for live performance and have emerged from my artistic practice as a cross-disciplinary artist and member of a performance art band. As a multi-tasking artist, the work I do does not exist in isolation but is interconnected inside a larger theatrical gesamtkunstwerk[1] (Smith 2007) frame and is informed by a variety of areas of practice including fashionable costume design, pop music, choreography, lens-based work and scenography.

As a performance artist, I always wanted to make a foot-centric device that considers the interconnected elements of the gesamtkunstwerk and makes an audiovisual statement—a requirement when performing theatrical music, live art and fashion performance scenarios. My underlying need was to create an audiovisual instrument for the feet. One that uses a theatrical prop to change what we can do with our feet and which can communicate social-political concerns, while simultaneously looking sublime. This fascination led me to the worlds of tangible digital musical instrument and footwear design, anthropology, propology and 3D design and fabrication. I endeavoured to merge key understandings from these cross-disciplinary areas to create a series of unique foot apparatus prototypes that include aspects of these fields.

A large part in the design of the *CEF* was developing the initial system. As a performer, many of my experiments and performances were within larger groups of performance artists, musicians, dancers and sports scientists and fabrication specialists. As such, the system needed to be flexible to be able to work in these contexts of spontaneous experimentation and improvisation in scientific and fabrication labs, rehearsal studios and on stages.

At the commencement of this practice-based PhD research project, I started to collaborate with technologist and musician Sam Ferguson who developed the main system I would go on to use throughout the project's trajectory. Updates and extensions of the versions and systems also occurred along the way, together with further collaborations with computer science and industry practitioners. Having this flexible working system enabled me to focus on designing and making the visual prototypes and their choreographed sounds, which I

[1] See Appendix A: Definition of Terms.

undertook as an artist-in-residence at various global cultural institutes, tech corporations and fabrication laboratories. The iterative process of developing the physical prototypes went hand-in-hand with developing the performative aspects of the instruments in vivo at music festivals, art performances and fashion-tech shows.

I embarked on several collaborative artistic projects using the *CEF* with a broad range of scientists, musicians, visual artists, choreographers and fabricators. These projects not only served in developing my artistic practice as a performer, designer and fabricator of foot-centric digital musical instruments, but also formed the core of my investigations for this research project. These projects also produced additional artistic outcomes in the form of music videos, photographic documentation and performance art works, which in a sense were led by the feet in a very intuitive way. These interconnected projects themselves demonstrate one of my main arguments about the state-of-the-art of digital musical instrument design—everything is interconnected. To overcome the challenges of designing a semantic and visually unique instrument, one needs to rely on intersecting 'ArtScience' collaborations and cross-disciplinary thinking in diverse contexts.

The *CEF* were in constant development and were used in over 200 live scenarios. During the process, I developed three types of *CEF* prototypes, with three major system changes. In doing so, I gathered and analysed observations and made reflections on the process of designing and developing these new audiovisual instruments. The core contribution of this thesis is the collecting and categorising of these observations and reflections on how to connect choreographed sound and a visual foot costume to make a semantic statement inside a gesamtkunstwerk.

I would like to express the importance here of ArtScience collaborations. I myself am not a technologist, nor am I a computer scientist or programmer. I am a performance artist and a designer/fabricator of foot costumes, whose specialty in the field of instrument design lies in imagining artistic ways that we can use the human foot to perform theatrically using audiovisual props.

This thesis will take the form of a narrative of the iterative making and development of these new instruments within the trajectory of my own artistic practice. I will document:

- the instrument's conception and materialisation in my artistic practice
- new encounters and unexpected outcomes and opportunities in different art, science, fabrication workshop and sports contexts

- key processes of iterative prototyping and performing that reshaped and redefined my own artistic practice
- reflections on and discoveries from the iterative prototyping and performing and how they affected the design and performance aspects of the prototypes
- design criteria for future prototypes.

This thesis is presented in six chapters. Following Chapter 1: Introduction, Chapter 2, firstly introduces my experiences as an artist researcher working with objectinstruments (self-made musical instruments) in performance art and pop theatrical music contexts in my group Chicks on Speed (COS). This is followed by a literature review of the state-of-the-art that includes natural science and anthropological concepts around the feet and footwear, shoe-based instrument designs and inventions, as well as ways of costuming the foot in the worlds of prosthetics, fashion, pop music videos, and theatrical and art performances. In Chapter 3: Methodology, I will outline my research questions for this practice-based research project, and justify the methods used. In Chapter 4: Case Studies I will describe the key iterative prototyping stages, projects and opportunities that involved the *CEF* explored throughout this PhD. The observations are mostly gathered from journal entries but also draw from reviews of performances and interviews with collaborators. These observations will be presented through descriptions of the key iterative prototyping stages, live projects and opportunities that I was involved in, detailing some insightful and recurring concepts of prototyping foot-based costumes. In Chapter 5: I will outline the development of new prototypes for underwater theatrical performance, which introduces the idea of making an instrument for a group of other artists to use collaboratively in their water performances. Chapter 6: Conclusion will be a brief and concise summary of this thesis.

Chapter 2: Background

2.1 Introduction

In this chapter I firstly present my art background working with body-centric self-made musical instruments which is the base of the work I go on to describe in this thesis. I will then describe concepts and histories about feet and shoes derived from a rich body of literature from a range of disciplines, including; anthropology, medicine, performance art, shoes and new musical instrument design. The aim of this chapter is to identify the various fields and writings that have motivated my creative practice and research enquiry over the last five years, relating to philosophical and cultural understandings of shoes in society and feet in performance.

The literature shows that shoes have important cultural, religious and social significance (Demello 2009). Feet and the shoes, which adorn them, have been the subject of philosophical writings, technical design and creative artworks as they provide a stable base for our bodies, they can hold great symbolism and they can also facilitate creative expression. As Lamontagne (2016, p. 20) writes, "Technology's role is to not only inspire fashion but also shape its form, function and aesthetics". This has indeed been the case for shoes, which have, for better or worse, been shaped by technology and which at times has resulted in the development of shoes that have the power to modify, reshape (and even deform) our feet.

In my creative practice and research, I explore and demonstrate the expressive role of the feet in performance art and their potential impact on the way we perform when enhanced with technology to produce a multi-sensory experience. This approach places computer-enhanced footwear in critical dialogue with contemporary technologies for shaping corporeal experience and reimagining foot-centric technologies, to inform unexpected outcomes and communicate ideas through internal bodily awareness. I also seek to challenge the 'un-free state of the feet' by employing shoe technology in somatic, performative, free, unpredictable and non-repetitive ways, rather than traditionally considering our feet solely for walking as "stepping machines" (Ingold 2004, p. 319).

2.2 Artist's Background

2.2.1 Introduction

I am co-founder of the cross-disciplinary art band Chicks on Speed (COS), a collective of culture workers who apply subversive do-it-yourself ethics to interrogate the boundaries of academia, pop music, craft, performance art, new musical instrument design, textiles and theatrical fashion. Melissa Logan and I co-founded COS in Munich in 1997[2]. Together we are the core of the group and share the group's everyday tasks along with the authorship of the works we create under the umbrella of COS. In addition, our solo works such as my practice based research into sounding footwear, usually flow back into COS performances and exhibitions, as working solo allows me to have concentrated time alone to experiment and develop personal work to a certain point, which I can then bring it back into the group to build upon.

COS have exhibited and performed internationally in art institutes, foundations and Biennales including the Museum of Modern Art (MoMA) in New York, Centre Pompidou in Paris, Tate Britain in London, 55th and 56th Venice Biennale, Haus der Kunst in Munich, ZKM Centre for Art and Media in Karlsruhe and the Thyssen-Bornemisza Art Contemporary 21 in Vienna. Our group has also had solo exhibitions at the Kate MacGarry Gallery in London, Milani Gallery in Brisbane, Artspace in Sydney, Deitch Projects in New York, Dundee Contemporary Arts in Scotland and the National Museum of Modern Art in Kyoto.

Our artistic endeavours are also the result of collaborations between international artists, scientists, musicians, philosophers, film directors and fashion designers, including Karl Lagerfeld, Jean Charles de Castelbajac, Isabel Coixet, Douglas Gordon, Jeremy Scott, Peaches, Red Hot Chilli Peppers and Lisa Walker. Over the last 21 years, core collaborating members of COS have included Anat Ben-David, Kathi Glas, A.L. Steiner and Krõõt Juurak, all of whom have also collaborated on specific parts of my practice based research described in this thesis.

My artistic practice in the field of New Interfaces for Musical Expression (NIME) began in 2007 as part of COS's growing archive of *objectinstruments*, a term Melissa and I coined to describe self-made body centric musical instruments (Logan, Murray-Leslie and Winter 2010).

[2] Kiki Moorse was an original member of the group from 1997-2006 and is now pursuing a solo career. Kiki sometimes joins Chicks on Speed on stage for special concerts.

We both engage collective strategies and take radical approaches to making our work and objectinstruments which demonstrates our ethos of the utopian *gesamtkunstwerk*–an all-encompassing work (in the style of Richard Wagner) that can be practiced on the street with your own amplification device, or in the cultural landscape of a museum.

2.2.2 Objectinstruments

Objectinstruments began out of necessity, like many things that take place in COS. In the beginning, we had a very minimal stage set up for live performances and felt there was something missing on the big stages where we were preforming.

It all started when Melissa and I performed at a show in Munich with F.M. Einheit[3], also known as Mufti (original member and percussionist of industrial band Einsturzende Neubauten). I was impressed by Mufti's custom-made metal instruments and tools, especially his giant spring with contact microphones that hung from the ceiling, and his hammer drill and bricks. Back stage I asked Mufti to explain what he was using as a technical set up. Following this experience, Melissa went off and started experimenting with contact microphones and a textile glove that she would speak into and stroke objects with during jam sessions in COS's early live shows. The glove caused a lot of audio feedback and was not always successful.

Such live experiments and risk taking has become an integral part of COS's live performances. Our group is not interested in perfection or virtuosity. Instead we choose to expose experimental processes live on stage, even at the risk of possibly disappointing the audience's expectations of a fun and perfect pop show product. That said, we also acknowledge that the shows need to work as a whole for our spectators. COS believes in strong performances which we've been building up over the last 21 years. We have made a serious commitment to continually surprise our audiences with new self-made musical instruments, shows and experiences, as we do not believe in repetition and embrace the fact that new NIME elements are often experiments in vivo.

We thought building our own musical instruments could be interesting for COS as we could create our own oeuvre of instruments with their own audiovisual style. This was

[3] For more information on Mufti's solo projects http://www.fmeinheit.org/ and his with Einsturzende Neubauten: https://neubauten.org/.

something other groups had not really done before, so it was interesting for us to explore new territory. As we didn't play classical musical instruments[4] or want to buy shop ready instruments that come along with large manuals and pre-set sounds, we instead set out on a mission to create theatrical prop-like musical instruments that would enhance and fill the stage in a meaningful audiovisual scenographic way.

2.2.2.1 Experiments with objectinstruments

One of COS's early experiments with objectinstruments included the *Log* (see Figure. 1).

Figure 1. *Log* and *Body Sensors* performed at *The hanging Garden Party 2*, Japan Fashion Week.

Initially a present (from one of Melissa's trips to outback Croatia), the *Log* became an objectinstrument once I attached contact microphones to it and began playing it with a drumstick and guitar effects pedals or Melissa's Mooger-fooger using LFO and Delay effects. Sometimes I would also wear sensors temporarily taped directly on the body, (sourced from

[4] Melissa learnt play saxophone growing up, but didn't play it in those early COS years.

COS's *Audiovisual dresses)* which I repurposed by mapping them to different one-shot vocal samples for solo performances.

Log also became a part of my solo collaborations/fashion performances titled *The Hanging Garden Party scene 1* presented at Paris Fashion Week in a side street and *The Hanging Garden Party Scene 2* presented at Tokyo fashion week in a gallery (a collaboration with Krõõt Juurak and fashion designer Pelican Avenue). Each location presented a new scene and dialogue between performance art, fashion, choreography and sound. In the Tokyo scene my body was wired with sensors linked to sounding samples of spoken letters and was used as a human instrument to spread the 'word'.

In another work called *Sleep Symphony*, our brains and bodies became the objectinstrument. For this work, Melissa and I participated in a three-hour sleep study[5] conducted at the Sleep Department of the University of Western Australia (see Figure. 2).

Figure 2. Melissa and I in the middle of a sleep study, Sleep Department, University of Western Australia, Perth.

The extracted sleep data was turned into a sonification (with my key PhD technologist collaborator, Dr. Sam Fergusson who I introduce in the case studies chapter) by developing sound maps that utilised interesting ethereal and haunting sounds via a polyphonic keyboard.

[5] See Appendix F: Project Acknowledgements..

The sleep data was also turned into a visualisation, which was projected onto a double bed in the gallery room space (see Figure. 3), resembling a decorative moving duvet cover.

Figure 3. *Sleep Symphony*, an objectinstrument exhibited at *Chicks on Speed:We are Data*, 401Contemporary, Berlin, 2015.

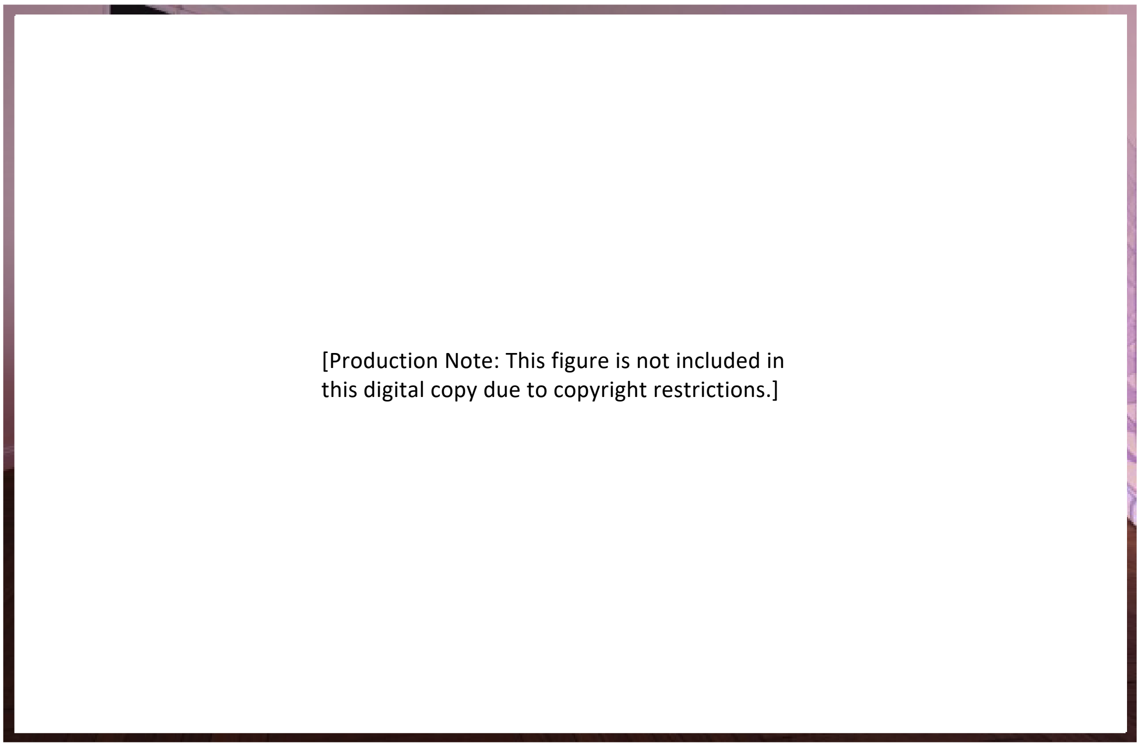

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Figure 4. *Sleep Symphony*, installation view, *Chicks on Speed: We are Data*, 401Contemporary, Berlin, 2015.

The bedroom scenario in the work also included dream like elements such as a *scanned chair* by Peter Weibel—an actual chair that had been sliced up and suspended inside plexiglass sheets, together with an image taken from the first experiments of this PhD and the *Prototype Hits* performance (which will be unpacked in the case studies section of this thesis). UV lighting was also used in the room, which made everything a slight shade of violet (see Figure. 4).

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Figure 5. *Self-contained amplification device.*

While COS uses objectinstruments during our live performances, to simultaneously function as scenographic props, fashionable costumes and audiovisual generators, the objectinstruments have also been used during studio recordings for our album releases[6] and our music videos. For example, the *Text Vodka and Le Rock n' Roll*[7] video uses our *Self-contained amplification devices* (hats), which can be worn with or without an aesthetic outer shell (see Figure. 5 which pictures the amplified hat with its outer shell).

[6] https://itunes.apple.com/nz/album/cutting-the-edge/317520081
[7] *Text Vodka and Le Rock n' Roll* music video featuring Peter Zinovieff wearing the prototype *Amplified Hat*: https://vimeo.com/107840149

Left Figure 6. Performance and installation with *Self-contained Amplification Devices* for the exhibition *The Making of Art*, Shirn Kunsthalle, Frankfurt, 2009.

Right Figure 7. *Selfcontained Amplification Devices*, performance, Rome Fashion Week, Alta Roma, Rome, Italy, 2012.

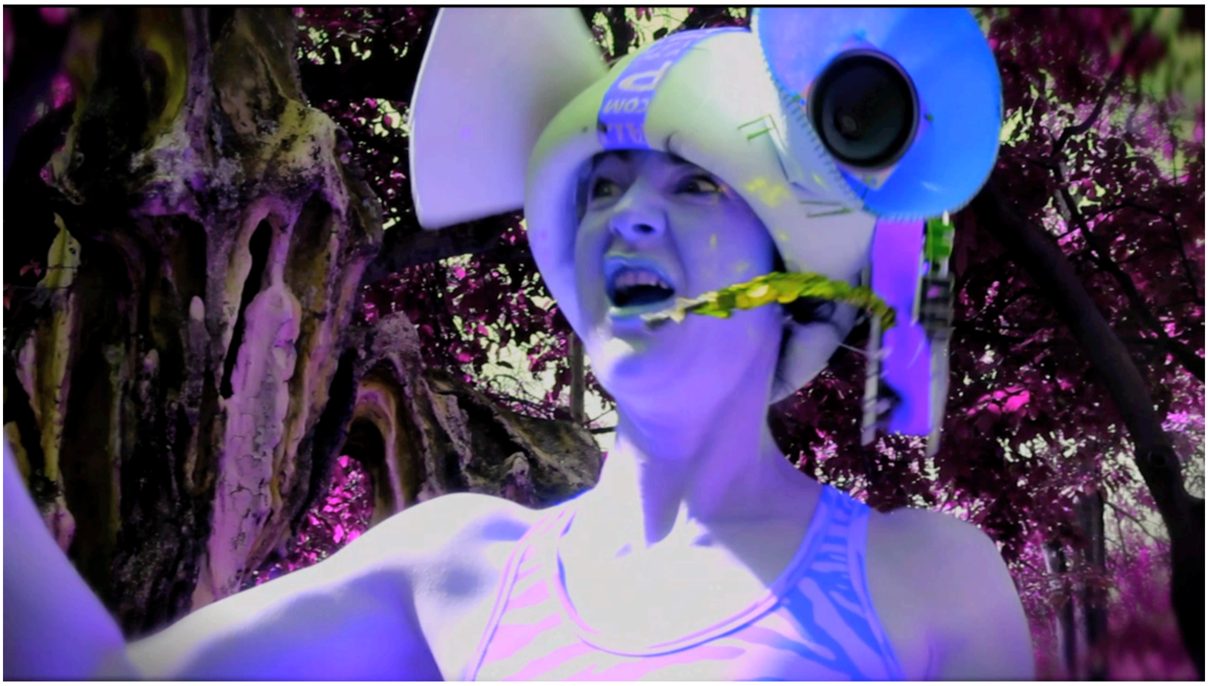

Figure 8. Melissa wearing sounding hat during short film, *Chicks on Speed at Haw Paw Villa*, Singapore. Courtesy of NTU, Centre For Contemporary Art Singapore, 2015.

The hats have also been used in several live artwork installations, fashion performances and short films (see Figs. 6, 7 and 8).

This multiple use of the objectinstruments in contexts ranging from fashion and pop music, to art and film has become a signature for COS and has bled quite naturally into my own work with audiovisual foot based prototypes (described in this thesis). A selection of COS's objectinstruments to date include:

- *Glove* (2003)
- *Scissors* (2005)
- *Cutter* (2008)
- *High Heeled Shoe Guitar* (2007)
- *Rocks* (2008)
- *Log* (2009)
- *Theremin Tapestry* (2009)
- *Audiovisual dresses* (2009)
- *Self-contained amplification devices* (2010)
- *E-Shoe* (2011)
- *Cigar box synthesizers* (2011)
- *Orbitalopia*, interactive gestural sound installation made from mixed media (2013)
- *Face Tracking*, *Andy Banana*, *Audiovisual synthesizer, Spray paint*, *Turntable*s, *E-Shoe*, a series of six iPad Apps as digital musical instruments (2015)
- *Molecule patchwork* (2015) based on the *Crackle Box* (Waisvisz 2004)
- *Sounding Textile Patchwork* (2016)
- *Sleep Symphony* (2016)

Overall, objectinstruments have enabled COS to extend ourselves and our performance range past the limits of our physical bodies. We have come to realise them as a part of a larger *gesamtkunstwerk*, and they only came to life in this context. For when isolated, objectinstruments merely function as sculptural documentary remnants of performances, fan souvenirs, dead art or experiments waiting to come alive.

2.2.2.2. Using feet to play objectinstruments

The *Theremin Tapestry* (2009) has been the lead protagonist in various COS exhibitions[8] and was featured in our short film *Golden Gang*[9] (2015). In the film, during a performance with *Theremin Tapestry*, one of *the Lycra ladies* is bound to become a 'body antenna' (in surrealist style) and is carried and motioned by the women to trigger sounds from the tapestry with her feet (see Figure. 9).

Interestingly, this is comparable to how the tapestry was played earlier at the opening of our exhibition *Chicks on Speed; ~~Don't~~ Art, Fashion, Music* at Dundee Contemporary Arts in 2012. In this performance, COS collaborator Faustine Komplewjski also performed the tapestry with her feet while wearing bright yellow high-heeled shoes (see Figure. 10).

Figure 9. *The Lycra Ladies* and Chicks on Speed performing *Theremin Tapestry* in the film *Golden Gang* by Chicks on Speed, *The Pinnacles,* Western Australia 2015.

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[8] To see information on the Scream exhibition series: https://www.artspace.org.au/program/exhibitions/2013/scream-chicks-on-speed/

[9] Link to the short film Golden Gang: https://vimeo.com/chicksonspeed/goldengang
Password: Lycraladies

Figure 10. Chicks on Speed *Theremin Tapestry* performance, vernissage;
Chicks on Speed: ~~Don't~~ Art, Fashion Music, Dundee Contemporary Art Centre, 2010.

Such uses of the feet as leading choreographic gesturer or player of various objectinstruments (instead of the hands) would be adopted more and more in both COS's and my own solo performances. While hard to pin point where this style originated, it seems to have begun on stage through improvisational work by Kroot, Melissa and myself during our shows.

Key feet-focussed works I have developed and performed with in COS include *The High Heeled Shoe Guitar*[10] and *EShoe*[11]. These seminal works, outlined below have formed the foundations of my own research into audiovisual expressive foot devices as described in this thesis.

[10] Performing with *High Heeled Shoe Guitar:* https://www.youtube.com/watch?v=AJiSfdINuag
[11] *Chicks on Speed: Don't Art, Fashion, Music* exhibition and opening performance with the *E-shoe,* staged at *Dundee Contemporary Arts* 5th June 2010 https://vimeo.com/43260701
https://www.youtube.com/watch?v=bb2AaO0Nky4

2.2.3 High Heeled Shoe Guitar

High Heeled Shoe Guitar was developed out of necessity. The aim was to have a costume-like prop for COS that would facilitate a kind of parody on a virtuosic guitar solo and simultaneously create a spectacle, in response to our song *We don't play Guitars*[12]. We needed an instrument to play during the song that resonated with the song's sloganeering anthem-like flair and which celebrated its electronic pop versus analogue indie rock music style. Initially, Melissa brought a classic electric guitar on stage, which I felt epitomised male rock music and did not suit COS. Out of desperation to avoid the male guitar trope, I concepted the *High Heeled Shoe Guitar.*

The *High Heeled Shoe Guitar* was developed initially as an analogue prototype that used a shoe purchased at the popular ready-to-wear fashion store Zara (see Figure. 11). My idea turned the commercial fashion item into a guitar that featured a pickup (sitting in the inner sole, making the shoe unwearable), three guitar strings, screws and an output jack. By modifying the every-day fashion commodity, the stiletto was transformed into a tool to empower the user to create.

Figure 11. *High Heeled Shoe Guitar*, 2007.

[12] https://www.youtube.com/watch?v=sK9XQLSpFBA

High Heeled Shoe Guitar resonates with the notion of 'commodity fetishism', a term invented by Karl Marx (1990), which describes an obsession with collecting fashionable high-heeled shoes, where by the purchaser elevates the shoes to a level higher than food or shelter[13]. *High Heeled Shoe Guitar* is a sub-cultural metaphor to question the obsession with fast-fashion trends and the consumption of fashionable goods. The work is also a celebration of the 'ready-made' as art object, and a tribute to the Dada artist Baroness Elsa von Freytag-Loringhoven.

Freytag-Loringhoven invented the concept of the ready-made 100 years ago, by sending Marcel Duchamp a urinal to be exhibited as an art object in the *Independents exhibition,* Paris (Gammel 2002). Freytag-Loringhoven's work has been a major influence on COS's own brand of objectinstruments, which build upon her legacy of erasing boundaries between art, life, stage and commodity, as well as provide 'ready-made' body adornments new meanings through our daring and outrageous public performances. *High Heeled Shoe Guitar* is a perfect example of this and other COS objectinstruments which have been described as "a fantastical approach to design that leads beyond utility towards the articulation of desire and absurdity" (www.katemacgarry.com 2009).

While usually only one of each objectinstrument is made, in the case of the *High Heeled Shoe Guitar* there are two, as I had to buy a pair of shoes it made sense to transform both, one for stage wear-and-tear and one for exhibitions.

High Heeled Shoe Guitar can be amplified like a standard electric guitar, by plugging it into an amplifier with a stereo jack cable, inserted into the back, upper heel of the shoe. The three strings are very short and effectively un-tunable, which means the shoe functions more as a 'sound instrument' than a traditional 'musical instrument', which has led to such solutions as the player (me), using guitar effects pedals, to create further notes and sounds. For example, by using a digital delay, metal zone or pitch pedal, experimental and random new sounds can be crafted.

The *High Heeled Shoe guitar* also encourages the player to physically play a guitar in a new way, creating individual and spectacle like moves and choreography for playing the objectinstrument, providing additional material for on-stage dramaturgy.

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[13] An example of high-heeled shoe obsessions is that of former Philippine's first lady, Imelda Marcos, who some would argue did put her collecting of 2,700 or more shoes above the well being of the people of The Philippines (Niu 1999), ABC calls is part of the 'the excess of a regime' http://www.abc.net.au/news/2016-10-02/imelda-marcos-shoe-museum:-the-excess-of-a-regime/7877098

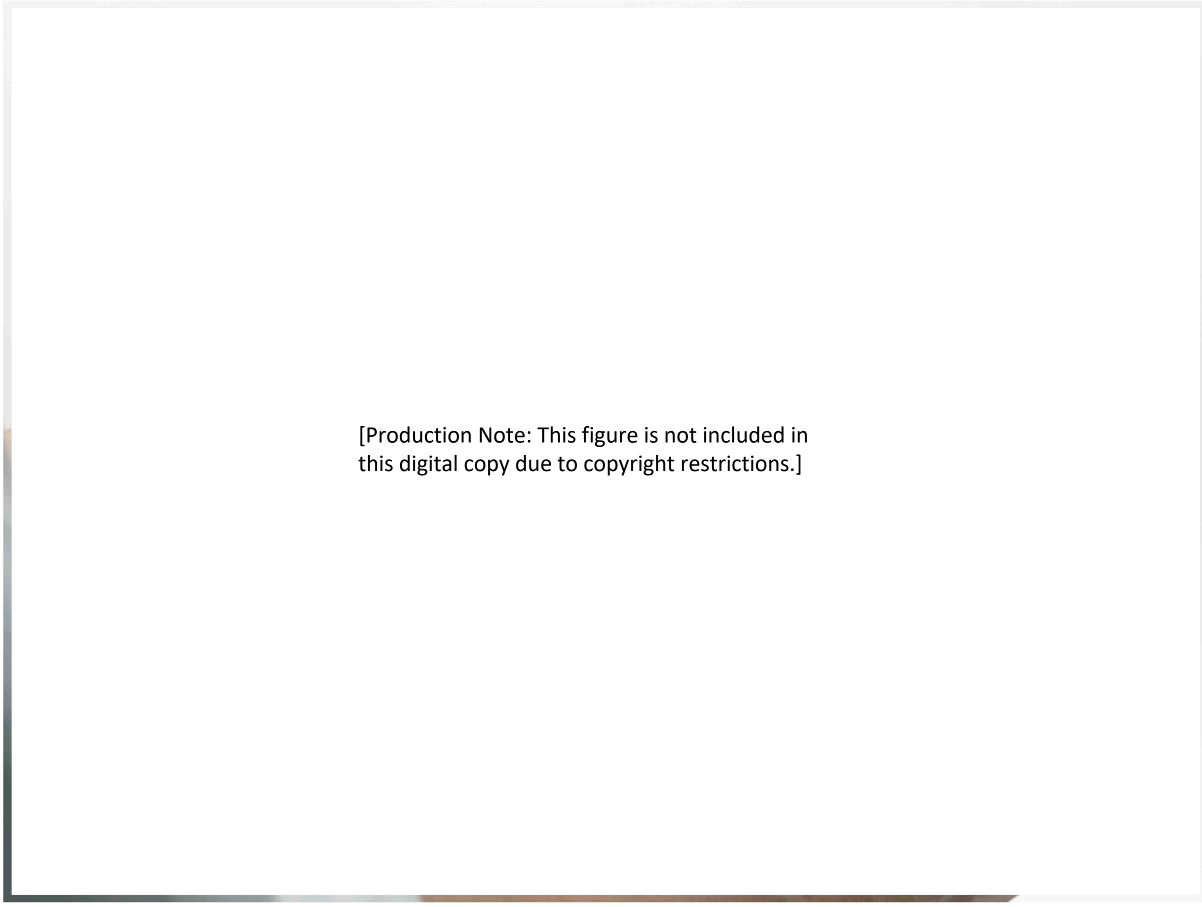
While the prototype high-heeled shoe guitar showed objectinstrument potential, it was also limited in some important respects. It was not wearable, had a comparatively limited sonic range and was played by the hands and not the feet. To attempt to address these problems, the *E-Shoe* was developed.

2.2.4 E-Shoe

> The *E-SHOE* controls the wearer, the wearer becomes statuesque, an icon on stage, not being able to move as the shoes are so high, as high as skyscrapers, you become a living sculpture, the wearer is dependent on a player, lifting her leg, the wearer of the e-shoe becomes a human guitar, a body sculpture to play, but powerful, like a high rise made of steel (Logan, Murray-Leslie and Winter 2010).

It took two years of research and development, to create the *E-Shoe*—the world's first wearable high-heeled shoe guitar (see Figure. 12).

The *E-Shoe* was developed out of the desire to create a wearable, fashionable and functional high-heeled shoe guitar that could play back sampled loops, enabling more complex on-stage jam sessions and music making. It was a kind of wearable interface for musical expression that explored new of ways to play sounds, collaboratively jam, develop performance dramaturgy and choreograph spectacles, as well as craft gestures, playing and mapping techniques that could exist in the worlds of art, music and fashion. In order to effectively meet the aesthetic and functional fashion requirements of the project, I wanted to work with an expert shoemaker, so I met with Milanese shoe designer Max Kibardin. I showed him the *High Heeled Shoe Guitar* to see if he would be open to collaborating on the next *E-Shoe* version. He said yes and our collaboration began.



[Production Note: This figure is not included in this digital copy due to copyright restrictions.]

Figure 12. *E-Shoe*, 2011.

Max's approach was to remix the original *High Heeled Shoe Guitar* design into a new *E-Shoe* design. During the process, the shoe went through two prototyping stages (see Figs. 13 and 14), with fabrication taking place in Milan. Fashion stylist Nicola Formachetti and her client Lady Gaga also played a role in the design of *E-Shoe* as they felt the shoe could be potentially worn by Gaga. Formachetti encouraged Max and I to develop the first prototype further when she emailed us saying that it was "boring and feminine, not what Gaga would wear" (Formachetti 2010, pers. comm., 25 September).

I made several trips to Milan to oversee the production of the two prototypes and eventually assemble the final *E-Shoe* in the factory. The final stages of assembly required me to file the heel flush, attach it to the plateau, drill holes in the bridge and put together the screw and guitar string elements. The outer surface was then spray painted in a car-tuning factory with high gloss colour (and glitter) variations.

Figure 13. Max Kibardin's prototype 1 design of *E-Shoe*, based on original *High Heeled Shoe Guitar*.
(Lady Gaga did not like this design. Her and her stylist's opinion pushed the project to the next prototype design).

Figure 14. *E-shoe* prototype 2, Left: Max Kibardin's second sketch for the prototype,
Right: milled aluminium form that enabled multiples to be cast in plastic.

Looking back, it was strange to go straight into the fabrication process without having had a mock-up to try on to test its wearability and playability. However, due to time constraints (the *E-Shoe* had to be ready for the opening of our solo exhibition at Dundee Contemporary Arts) and the limited accessibility (as well as high cost) of 3D printing at the time, I decided to go ahead into the fabrication phase without any testing. This meant that there was no going back and what I received would be the final shoe. While highly fashionable and aesthetically pleasing, the *E-Shoe* is quite difficult to walk in and perform in—a direct result of not making a prototype test shoe before going into fabrication. Nonetheless, I have found that such 'mistakes' can positively influence the way objectinstruments function on stage. Given the *E-Shoe's* twelve-inch plateau, it was impossible for the wearer to play their own shoe. This resulted in having to engage a co-performer to 'play' the wearer's leg and shoe, which resulted in a visual metaphor being created on stage that represented and mimicked typical guitar solo performance (see Figure. 15). While it was not a planned outcome for *E-Shoe*, it was a great happenstance to have occurred during COS's experimental performances.

Figure 15. Chicks on Speed performing *E-Shoe* at the opening of *Chicks on Speed: ~~Don't~~ Art, Fashion, Music*, Dundee Contemporary Arts, 2011.

With regards to *E-Shoe's* music making capabilities, the shoe's strings do not function like the strings of a traditional guitar. To play the *E-Shoe*, the player has to simply touch the different strings, which are attached to sensors (walking or vibration does not generate any effects with the strings). This triggers midi-notes to be sent to a wireless transmitter (an Xbee radio transmitter and circuit board in the shoe, see Figure. 16), which then transmits the notes to a wireless midi-receiver. The notes are then mapped to an audio sample and effect parameter in Abelton Live music software.

The technical design of the *E-Shoe* overcomes music arrangement issues experienced with *High Heeled Shoe Guitar* as the complex mapping in Abelton Live enables the player to play samples simultaneously, thus creating layers of sound that can be turned on and off, resulting in a meaningful composition.

The *E-Shoe* has also been the most publicised of all the objectinstruments used by COS, being the spotlight at COS music shows and performance lectures[14], publications[15], and exhibitions[16] such as *The Power of Making* (see Figure. 17*)*. the *E-Shoe* was even worn by Kate Moss (see Figure. 17) for *Vogue Brazil* and was also photographed by Terry Richardson for *Purple Fashion* Magazine[17]. As Glen Adamson, Head of Research at the Victoria and Albert Museum describes:

> If these shoes are experiments, then, where can they take us? They certainly aren't made for walking. Though the Chicks have performed with them on stage (in the museum gallery no less), they also seem perfectly at home under lights, on a plinth. And there is something about them that denotes their makers' interest in celebrity. Later prototypes were designed with Lady Gaga in mind; even for her, they'd arguably be an upgrade. So these are shoes that are made to be looked at. But at the same time, they feel empowering, and not just in the way that spiky heels usually do. If a shoe can be an electric guitar; if fashion designers can be contemporary artists and pop stars, all at once; and if a museum gallery can be a nightclub, then who knows what else might be possible? (Logan, Murray-Leslie and Winter).

[14] Performance lectures featuring the *E-Shoe*: *Mis en abyme* by COS with Milovan Faronato, Milan art fair, 15th April, 2012 https://vimeo.com/58623010 and *Don't Art Fashion Music Book Launch & Happening*, Mutt, Barcelona, 20th May, 2011 https://vimeo.com/24061778

[15] https://www.artsy.net/artwork/chicks-on-speed-e-shoe
http://www.vogue.it/en/talents/contests-and-more/2010/11/max-kibardin-e-shoe
https://www.thewire.co.uk/in-writing/interviews/chicks-on-speed.2
http://espresso.repubblica.it/visioni/lifestyle/2010/12/16/galleria/chicks-on-speed-il-fai-da-te-egrave-fashion-1.108200#5
http://www.refinery29.com/check-out-this-wireless-high-heeled-electric-guitar-shoe

[16] *The Power of Making*, 6 September 2011 - 2 January 2012 http://www.vam.ac.uk/content/articles/p/powerofmaking/

[17] Terry Richardson photographed the *E-shoe* for *Purple Fashion* 14, F/W, 2010: http://purple.fr/magazine/fw-2010-issue-14/ they also featured in *Terry's Diary*: http://www.terryrichardson.com/diary/#/2010-12/65/3

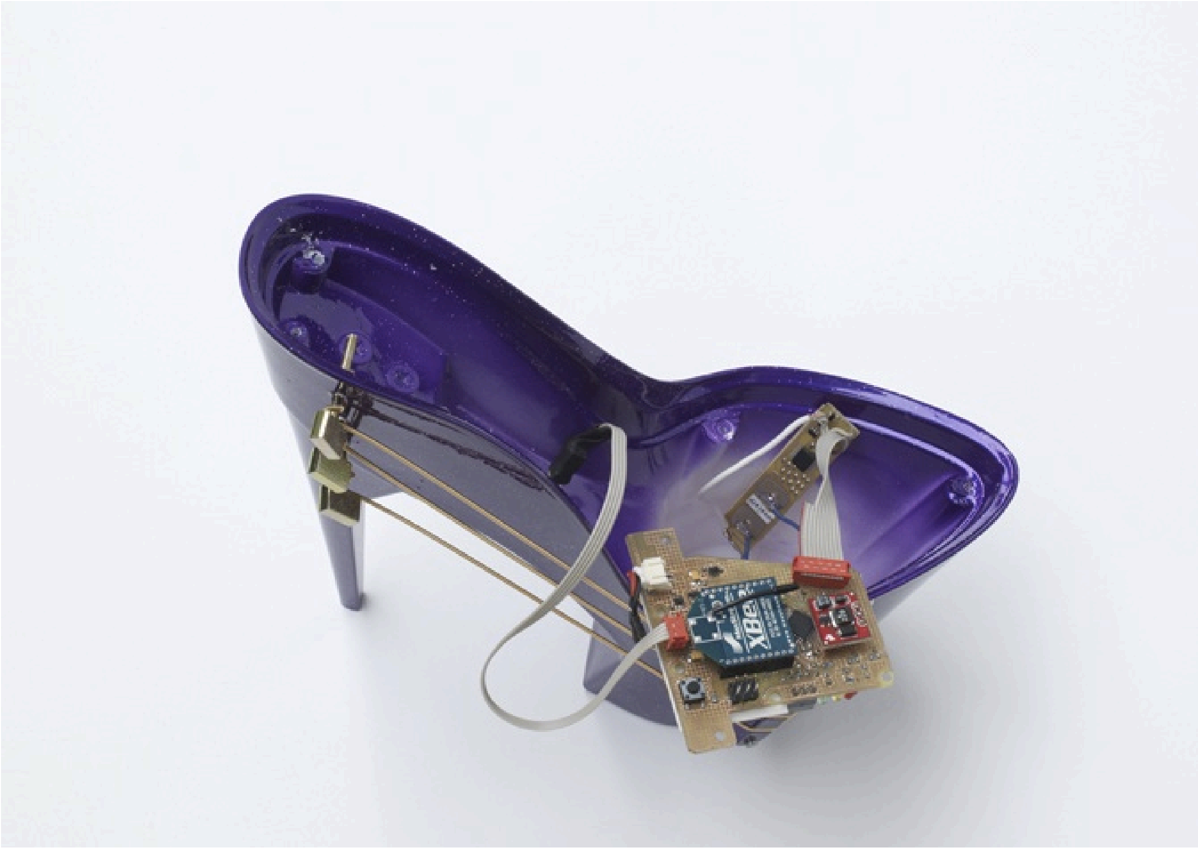


Figure 16. *E-Shoe* open plateau with bespoke circuit, sensors and XBee transmitter 2011.

Figure 17. Left Kate Moss wearing *E-Shoe* for *Vogue Brazil*, photo by Mario Testino, 2012.
Right: *E-Shoe* exhibited next to Alexander McQueen's *Armadillo Shoes*, *The Power of Making*, V&A London, 2012.

2.2.4.1 E-Shoe iPad App

An iPad application was developed around the *E-Shoe* to extend the instrument's capabilities, create visual spectacles onstage and enable audience members to compose, mix, and manipulate COS's audiovisual material. The *E-Shoe iPad App* was originally exhibited as part of the *SCREAM* touring exhibition framework together with five other interactive apps during 2012 to 2013, developed in residency at the ZKM Centre for Art and Media in Karlsruhe, Art Space in Sydney and the Institute of Modern Art (IMA) in Brisbane. The *SCREAM* exhibition also included a giant multifaceted sculptural object which functioned as a stage, a canvas and a playable musical instrument, activated through COS's array of sounds, rhythms, words and images 'performed' by visitors using iPads.

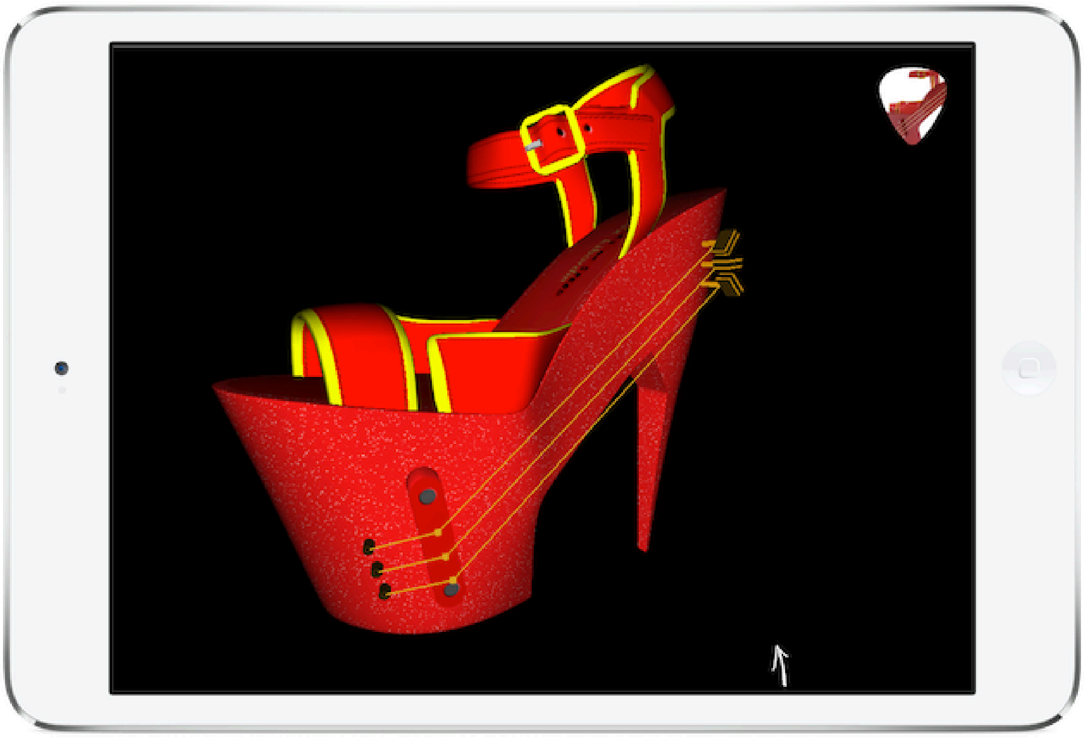


Figure 18. *E-Shoe iPad App*.

The *E-Shoe iPad App* had the following added functionalities, which the *E-Shoe* could not perform:

- pitch samples, created by moving the finger up and down the string, whilst triggering a sample
- pre-set filters
- projections to make *E-Shoe* was visible to audience members
- colour changing abilities to visualise *E-Shoe* in any colour on the pantone spectrum
- participation and interactivity between COS and the audience.

E-shoe iPad App was well received by users. As indicated by a series of interviews with 27 audience members at the *SCREAM* exhibition at IMA[18], the favourite objectinstrument of the exhibition was the *E-Shoe iPad App*. This was because it could be easily played without previous knowledge, it worked well with other instruments in the exhibition and it facilitated users to enact instrument playing gestures, making them feel like performers in the exhibition (further enhanced by the available sculptural stage platform).

2.2.5 High-Heeled Shoes as subjects

I have used high-heeled shoes in my solo work as well as my work in COS, not only as instrumental and amplification devices to perform with, but also as key artwork subjects.

Melissa and I utilise high-heeled shoes in our work to reprise the attitude of punk and combine it with strategies of 1960s women's feminist performance art (while adding a 21st century and late-capitalist twist) (Rees 2007). Our use of high heels as subject was especially evident in a series of photographs and paintings we created with artist Douglas Gordon as part of the *Shoe Fuk*[19] exhibition at the Contemporary Art Centre, Vilnius (see Figure. 19) as well as our song *Time Ripples*[20], which featured audio recordings of high-heeled shoe footsteps.

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[18] *SCREAM* by Chicks on Speed, Institute of Modern Art, Brisbane, 3rd August – 21st September 2013 http://www.ima.org.au/chicks-on-speed-scream/
Some comments by viewers of the exhibition about the *Objectinstruments* and in particular, the *E-Shoe:* https://artstudentadventures.wordpress.com/2013/11/06/scream-and-shout/
[19] *Shoe Fuck!* by Chicks on Speed, curated by Simon Rees, Contemporary Art Centre, Vilnius 8th September – 28th October, 2007 http://www.cac.lt/en/exhibitions/past/07/2225
[20] *Time Ripples* by Chicks on Speed https://www.youtube.com/watch?v=TlQJVjSax7w

Figure 19. Poster for the exhibition *Shoe Fuk!* by Chicks on Speed and Douglas Gordon, Contemporary Art Centre, Vilnius. Photo by Chicks on Speed and Douglas Gordon, 2007. Courtesy of Thyssen Bornemisza Art Contemporary 21.

A key solo project of mine featuring high-heeled footwear is the performance work *These Shoes are Made for Painting*[21], which I created in collaboration with shoemaker Max Kibardin and artist Anat ben-David. The live piece was an experiment encompassing moving bodies, high-heeled shoe commodities, colours and mapped sounds, which took place on 3 July 2011 at my studio in Sabadell, Spain.

The piece began with improvised walking. Each actor in the performance wore plain underwear and golden high-heeled shoes while they walked with their own personal gait and internal metronome. Then each performer, with blobs of coloured paint in hand, began to paint each other's shoes and legs, with broad gestural strokes—transforming the shoes from shiny golden commodity objects, into messy, non-market messy, painterly artefacts. Each colour was mapped to a specific tone spectrum in FM sound synthesis using camera vision in conjunction with Max/MSP, so when the painting and movement started, a sound composition commenced and built up depending on the available amount of colours and movements. When two performers crossed each other, the colours mixed, resulting in the sounds to also become 'mixed' through the use of different sound and audio filters.

[21] Media report: http://www.vogue.it/en/talents/contests-and-more/2011/03/these-shoes-are-made-for-painting#ad-image70620

The outcomes of the project included a chance acoustic and fashion-object audiovisual composition, a documentary video (which was exhibited at Le Struch, Media Art Centre, Sabadell, Catalunya), as well as a series of painted high-heeled shoes, which were exhibited at Milan Fashion week[22]. The piece also activated coloured surfaces as a means to explore how new technologies might be tested in the realm of performance art and sonic representation, in connection with the body. The sonification of interacting coloured bodies in the piece produced predictable and chance compositions, and experimented with "how colour alone can connote the gendered issues of artifice, makeup, dress up, and made-up frivolity" (Kunimoto 2013, p. 474).

2.2.6 Conclusion

In this section I have outlined the use of objectinstruments in both my solo work and my work as a member of Chicks on Speed. I have explained how they inform improvisational interaction individually with one's own body parts, with other performers and sometimes with audience members. I have also described my approach to practice-based research, which explores the use of sounds and data via sonic interfacing garments or interactive body devices during live performance improvisation (and sometimes acts of necessity to overcome manufacturing 'mistakes') to transform and amplify audiovisual and aesthetic possibilities.

The importance of performance in the iterative design process has also been explored through my explanations of how the performer's ongoing experiences with an objectinstrument can influence stage presence and theatricality as well as result in individual traits being embodied in an objectinstrument acoustically and aesthetically. I also demonstrated how data collected through performance research studies can help to define new creative ways to design, play and refine instruments—an approach that breaks away from the conventional process of first designing an instrument and then rehearsing with it.

Finally I have also described the value of using the feet in different ways, such as performing them in the air and using them, instead of hands, to play objectinstruments.

[22] Milan fashion Week Diane Pernet blog post:
http://ashadedviewonfashion.com/2011/02/27/max-kibardin-milan-fashion-week-report-by-alex-murray-leslie/

2.3 Head over heels: Perceptions of feet

> In anatomical terms, the foot is a complex organ made up of twenty-six bones permitting humans to move through space (to walk, stagger, run and jump). At the same time, though, the foot provides the metaphorical ground for a series of ontological concepts and value judgments that bring the body and world into being. In Austinian terms, we might say the foot is doubly performative, a speech act in movement (Lavery 2012, p. 3).

Macfarlane suggests "we don't intuitively imagine the foot to be an expressive or perceptive body part, it feels more of a prosthesis, there to carry us about, rather than to interpret and organize the world for us. The hand always out skills the foot: We speak of manipulation but not pedipulation" (2009, pp. 16-17). Hashimoto et al. (2013) indicate that early hominids developed finger dexterity and tool use ability before the development of bipedal locomotion, further supporting ideas that the hand developed finger control for tool use, while the big toe evolved for balance and bipedal locomotion. It is interesting that the hand developed finger control and the foot mainly developed a big toe to balance human movement. This could be why little focus has been put on feet and their tools, or the foot as being able to carry out complex tasks. The foot's role is reduced to providing balance during mobility.

Scientific enquiry into hand gestures by John Bulwer (1644) proposed the hand is "the mind of the body" (Bulwer 1644, cited in Bulwer 1974 p. xiii) Bulwer's pioneering work on hands included creating sign language for deaf people, and the publication *Chirologia: or the natural language of the hand* (Chirologia meaning hand and speech in Greek). Bulwer was convinced that the hand had a meaning:

> [The hand] speaks all languages, and as universal character of Reason is generally understood and known by all Nations, among the formal differences of their Tongue. And being the only speech that is natural to Man, it may well be called the Tongue and General language of Human Nature, which, without teaching, men in all regions of the habitable world does at the first sight most easily understand (Bulwer 1644, p. 3).

Contemporary linguistics scholars also place priority of the hands with terms such as 'echo phonology', whereby characteristic mouth actions are echoed by articulatory actions of the hands (Woll 2014) and there is a transfer of manual actions to oral ones. Some go so far as to proclaim that the hands are the head of the mouth (Boyes-Braem & Sutton-Spence 2001).

Overall, this literature, which has attracted academic attention from scholars, philosophers, biologists, ethnographers, anthropologists and naturalists, describes a form of prioritisation of the hand over the foot.

Based on the concepts of T.H. Huxley's *Evidence as to Man's Place in Nature*[23] (Huxley 1863 & 2009), Ingold suggests through a series of developments in human evolution, the bias of 'Head over Heels' was formed and came to be seen as a key differentiation to our non-human primates. These include:

- enlargement of the brain,
- the remodelling of the hand (the special ability of humans to be able to touch the tip of the thumb with the tips of all fingers, allowing great dexterity to do manual tasks with the hands)
- the straightening of the legs and being able to stand upright and walk in bipedal motion (Ingold 2004).

This differentiation to non-human primates, also brought with it a bias against humans being close to the ground, or ape like, and in Darwin's opinion a separation was created (Darwin 1871). I believe this bias (temptation of the hands and fingers over the feet and toes, due to their fine dexterity and embodied skilled actions) has led us to cover our feet and treat them poorly. As a result, we do not use them to their potential and fail to recognise that feet 'can' have their own set of tools and evocative objects that we can think and move with, thus informing affordances, experiences and unusual outcomes.

Classical accounts of human evolution posit a progressive differentiation between the hands as instruments of rational intelligence and feet as integral to the mechanics of bipedal locomotion. The bias of 'Head over Heels' follows a long-standing tendency, in western thought and science, to elevate the plane of social and cultural life over the ground of nature.

[23] Huxley was a self-taught British biologist, who presented arguments using comparative *anatomy* (the comparing of anatomy between species, for example Huxley referred to *man-like apes*, comparing Neanderthal bone fossil remains of prehistoric craniums to modern human skulls, or the hands and feet of Gorilla's to that of man's) in making his arguments regarding the theory of evolution and specially the controversial idea of the ape ancestry of humans. His book is a compilation of his public lectures based on Darwin's theory of evolution. Huxley argued that for humans to understand the universe, they must first understand their place in nature (Huxley 1863 & 2009). Huxley was also known to agree with British scientist and physician Edward Tyson, the founder of comparative anatomy (Newman 1975), who is quoted as saying: "*Men* too have been observed to use their *Feet* like *Hands,* as I have seen several" (Tyson 1751, p. 91).

Charles Darwin in *The Descent of Man*, drew particular attention to what he called 'the division of physiological labour' (Darwin 1871, p. 35) by which "the feet and hands came to be perfected for different but complementary functions, of support and locomotion on the one hand, and of grasping and manipulation on the other" (Ingold 2004, p.). Most authors agree:

> The primary purpose of shoes is to protect the feet and allow for locomotion, we often purchase shoes with comfort, health, and even fit as our lowest priority. Instead, throughout history elites have worn stylish but impractical shoes, and today many people—but especially women—continue to choose shoes based on how they look. They convey not only our status, but for women they enhance our sexuality as well (Demello 2009, p. xxii).

Ingold (2004) also goes so far as to say that a more grounded approach to the way we move as humans can open up new terrain in the area of embodied skills of footwork. I would suggest such embodied foot skills can be learnt by playing foot based musical instruments in the air (as described in this dissertation). Practicing new and unexpected ways of moving the feet around new tools created specifically for the feet (and that are technologically assisted, promoting digital creativity), supports Ingold's concept that the feet can do more than just act as "stepping machines" (Ingold 2004, P. 319). Concepts expressed by Ingold have partly guided my decision to use the shoe devices in aerial mode (working against gravity) and not with the feet anchored on the ground (working with gravity). This approach differs to the many past shoe inventions for musical performance that have been used in a grounded manner, such as tap shoes.

'Prehensile feet' are lower limbs that possess prehensility: the ability to grasp like a hand. They are most commonly observed in monkeys, who similarly possess prehensile tails. Due to the development of bipedalism in humans, the hands became the focus of prehensility and the feet adjusted to more of a stabilizing role.

> Whereas the feet, impelled by biomechanical necessity, undergird and propel the body *within* the natural world, the hands are free to deliver the intelligent designs or conceptions of the mind *upon* it: for the former, nature is the medium through which the body moves; to the latter it presents itself as a surface to be transformed (Ingold 2013, p. 318).

Danielle Wilde (2015) questions this role of the hands as being the only body part to carry out tasks to create experiences:

> People generally have a high level of dexterity in their fingers and hands. Engagement with this part of the body can be efficient and fine writing provides an ideal example. Yet being seduced by this potential overlooks the value of full body, even clumsy interaction, often experienced at a lower resolution of control. Dexterity and efficiency may be viewed as something to strive for, yet fine motor control results in actions becoming disassociated from the experience of the action as focus necessarily moves through the body to the task at hand. If this did not happen, attention would be caught in the manipulation of the tool and the associated fine detail of motor control, and the task would suffer (Wilde 2015, p. 5).

Sitek and Sitek (2016) also support Ingold's notion of the feet supporting the hands and in turn possibly restricting the feet from doing anything else but walking and carrying out the act of balance suggesting that:

> It may be possible, however, that the foot does not reach its limits of dexterity due to the constant muscle tension needed in stabilizing and balancing the foot to hold up the legs and the rest of the frame (Sitek & Sitek 2016, p. 2).

In cases of people who are born without or lose their arms or hands, the feet, like the tongue and other parts of the body, are explored in greater function to stand in for the absent hands in performing daily human tasks. In many cases, greater prehensility is developed out of necessity and practice, such as being able to type on a keyboard at impressive speeds or learning to play a musical instrument.[24]

2.3.1 The feet as base

Bias against the feet, was a subject and artistic theme adopted by surrealist artists and writers. For example, in the 1929 essay *The Big Toe*, French philosopher Georges Bataille describes the taboo represented by that lowest of human features saying, "The play of fantasies and fears, of human necessities and aberrations, is in fact such that fingers have come to signify useful action and firm character, the toes stupor and base idiocy" (1986, p. 22). Such attitudes towards the

[24] Channel 4 trailer for Rio 2016 Paralympic Games: *We are the Superhumans*: https://www.youtube.com/watch?v=IocLkk3aYlk. The video features several people performing and playing musical instruments with their feet.

feet help explain perhaps why so little care has been taken to create shoes that promote good health for the feet by not restricting, torturing or deforming them.

> Although within the body blood flows in equal quantities from high to low and from low to high, there is a bias in favour of that which elevates itself, and human life is erroneously seen as an elevation. The division of the universe into subterranean hell and perfectly pure heaven is an indelible conception, mud and darkness being the principles of evil as light and celestial space are the *principles* of good: with their feet in mud but their heads more or less in light, men obstinately imagine a tide that will permanently elevate them, never to return, into pure space. Human life entails, in fact, the rage of seeing oneself as a back and forth movement from refuse to the ideal, and from the ideal to refuse-a rage that is easily directed against an organ as *base* as the foot. The human foot is commonly subjected to grotesque tortures that deform it and make it rickety. In an imbecilic way, it is doomed to corns, calluses, and bunions, and if one takes into account turns of phrase that are only now disappearing, to the most nauseating filthiness: the peasant expression 'her hands are as dirty as feet' while no longer true of the entire human collectivity, was so in the seventeenth century (Bataille 1986, pp. 20-21).

Bataille describes the human foot as 'base', which has several connotations as:

> **Base** *adjective*
> Contemptible, cowardly, degrading, depraved, detestable, dishonourable, evil, ignoble, immoral, inferior, low, mean, scandalous, selfish, shabby, shameful, sordid, undignified, unworthy, vulgar, vile.
>
> **Base** *Noun*
> the lowest part or edge of something, especially the part on which it rests or is supported
> *synonyms:* basis, bedrock, foundation, core, essence, essential, nitty-gritty, basics, starting point, key component, fundamental, root(s), heart, backbone, theory, principle, rationale.
> a conceptual structure or entity on which something draws or depends.
> a foundation or starting point for further work.
> a main or important element or ingredient to which other things are added. (Oxford Thesaurus of Current English, 2003, p. 30).

Figure 20. Antoni Tapies, *Foot-Cross*, terracotta, 1987.

If the base of the human body is the feet and the meaning of base has had the aforementioned connotations over time, some interesting parallels can be drawn as to why shoes and feet are connected to certain negative contemporary connotations and how we fell into a negative pattern of mistreating our feet. For example, base also has the meaning of ‘pedestal’, which is interesting in the context of Barcelona born artist Antoni Tapies who exemplifies this in experiments depicting the feet as sculptural metaphors such as foot pedestals or foot cross/ tombstones (see Figure. 20). The term ‘pedestal’ also relates well to many women’s ready-to-wear high-heeled and extreme high-heeled shoes, that look more like an ornament, sculpture or pedestal to present the rest of the human body on. These types of shoes can also be considered as grotesque tortures that deform and disable one’s feet if worn for long periods of time. One could suspect, the feet being base allows them to be deserving of torture for their lowly position. Kodwo Eshun (2017) suggests the feet are colonised by the body. They play the role of support structures or even infrastructure for the rest of the body, especially for the hands. The hands, the head and the eyes are the glorified organs of vision, manipulation, tactility and calculation and the feet are a kind of infrastructural support that philosophers never bothered to speak about that much (with notable exceptions such as Bataille). Eschun (2017) believes in order to undo the division of labour as proposed by Charles Darwin (as unpacked later in this chapter), one would have to effectively want to challenge, suspend, reverse, invert or maybe undo that division of labour, which brings up colonised questions, the feet are colonised by the body, the feet are the colonial subject, the feet are being colonised by the body.

This thesis supports Eshun's notion and aims to free the feet from the colonising body, which for too long has elevated the hand at the expense of the feet.

2.4 Are Shoes Modern? Foot Coverings and unliberated feet

Humans have worn shoes for 40,000 years. Anthropologists suggest that, initially, shoes were developed as foot coverings, for protection for the feet (Trinkaus 2008) and later, became fashionable or status symbols, collectables, subjects in art and fetish objects (McNeil & Riello 2011). I suggest, shoes are more than tools to just to carry us around, they can be reimagined to express our feet in unusual ways (Murray-Leslie 2016), such as through foot based audiovisual instruments (Murray-Leslie & Johnston 2017).

According to Leroi-Gourhan (1993, p. 102) "the tool is a criterion for humanity" and "the human and the tool invent each other" (Stiegler 1998, p. 175). Likewise, Culkin suggests, "we shape our tools and thereafter our tools shape us" (Culkin 1967, pp. 51-53). Similarly, as Pels believes, "not only are humans as material as the material they mould, but humans are moulded, through their sensuousness, by the "dead" matter with which they are surrounded" (1998, cited in Hockey et.al. 2015, p. 101).

Not only have shoes been made to fit feet, but feet have also been made to fit shoes. Foot binding, practiced by the Han ethnic majority in China, began around the tenth century and ended at the beginning of the twentieth century (it was initially banned in 1912, but continued in rural regions and was prohibited again in 1949 when the communist party came into power). A young girl's feet were painfully bound at a young age of five or six to stop their feet from growing so they could fit into tiny shoes which were a sign of beauty and a prerequisite for finding a husband. Their feet called 'Lotus Feet' (see Figure. 21) were deformed, with many women disabled and unable to walk, leaving them to be carried around (a sign of status for wealthy women who didn't have to work in the fields or even walk). When it was banned, some girls and women were ordered to unbind their feet. Such unbound feet, were known as 'liberated feet'.

Figure 21. Photo of deformed foot or 'Lotus Foot' due to the process of foot-binding, The Peabody and Essex Museum, Salem, Massachusetts (Bossan 2004).

Architect, designer and social historian Bernard Rudofsky curated the MoMA exhibition *Are Clothes Modern?* (1944), and wrote an essay in 1947 about contemporary apparel, which included a photograph (see Figure. 22) to show how modern shoes do not match the shape of the human foot. He and collaborator Berta Rudofsky also engaged in discourses around shoes being designed for the individual rather than for the masses[25]. *Bernardo Sandals* was founded by Bernard Rudofsky and Berta Rudofsky in 1946. Their designs were representative of the core ideas they both shared regarding 'closed footwear' (Rudofsky 1947, p. 37), which they described as 'foot-deformers' (Rudofsky 2014, p. 103). It is also the case that some shoes, particularly high heels, don't just deform feet but have adverse effects on other parts of the body.

[25]In his book "The unfashionable human body", Rudovsky sees shoes in general, including pointe shoes as body-shaping technologies, in part because designers have overwhelmingly sought to mould the foot to the shoe rather than the shoe to the foot.

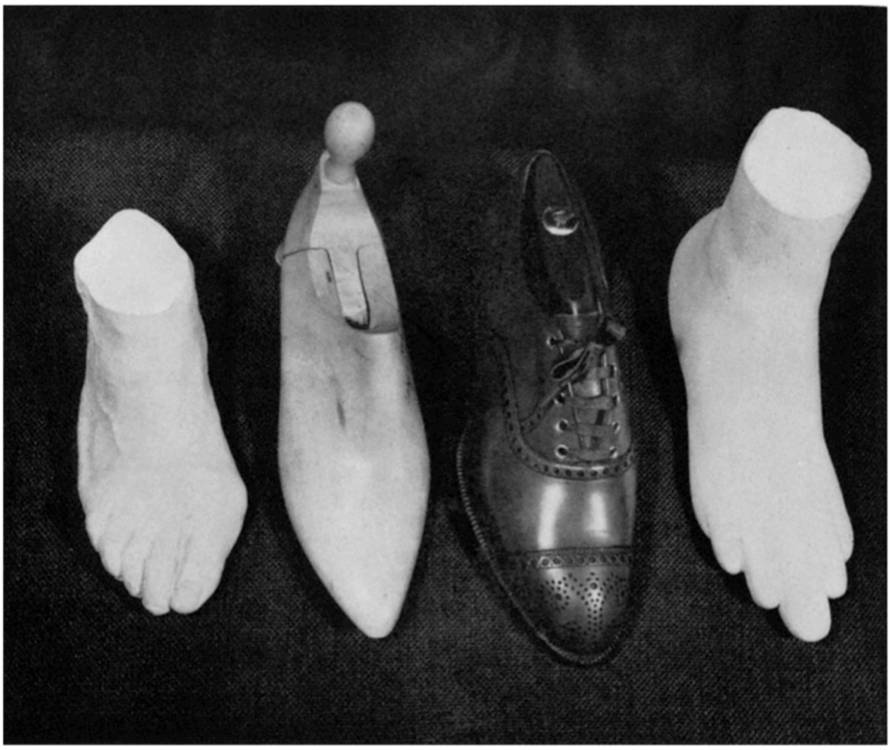

Figure 22. Bernard Rudofsky, 1947, gelatin silver print, © Bernard Rudofsky estate.

Overall, it would seem that there is an underlying phobia of the feet. As Bataille writes:

> Man's secret horror of his foot is one of the explanations for the tendency to conceal its length and form as much as possible. Heels of greater or lesser height, depending on the sex, distract from the foot's low and flat character (Bataille 1985, p. 21).

This perception is also demonstrated in the fairy-tale story of *Cinderella*, which was made popular by Charles Perrault in 1697 (DeMello 2009). The story has taken many different forms and existed in several different cultures but the message stays the same: the shoe can change the life of a girl but only if she has small and slender feet to fit into the gilded or glass slipper. Thus reflecting the importance of how cultures perceive and treat their feet; and how this concept of small feet being beautiful, and big feet being ugly, has inevitably influenced women's choice of footwear today:

> Whether or not the story originated in China or Egypt, it is clear that the motif of the small slipper only has power in cultures in which large feet are considered unattractive and unfeminine, and where the woman with the tiniest feet must automatically be the most beautiful and well-bred of all (and the stepsisters, with their large feet, are considered grotesque) (De Mello 2003, p. 63).

2.4.1 High-heels: Foot modifications and unwalkability

High platform shoes have not just been a recent fashion phenomenon. In fact, they date back to the 15th century in Europe when upper-class women and courtesans teetered on 11-inch high blocky platforms, called chopines. They were so impractical that according to Elizabeth Semmelhack, curator of the Bata Shoe Museum in Toronto, wearers required a servant or a courteous person to assist them in walking (ibid. 2008). Semmelhack also adds, that paintings of the period, depict women "towering over other people, which was a way of elevating one's self above one's peers" (ibid. 2008).

High-heeled shoes also change the way humans walk, forcing humans to adapt to the shoe, also having the potential to disable naturally healthy feet, as with high-heeled shoes (or stilettos[26]) when worn continuously. As Wikler confirms, "the introduction of the elevated heel and the pointed toe marked the beginning of modern foot disabilities" (1961, p. 23) (see Figure. 1). Kathryn H. Anthony (2017) believes that contemporary high-heeled shoes are dangerous, with many women and doctors reporting ankle sprains and breaks and other foot injuries based on data from emergency-room visits associated with high-heeled shoe wear. Researchers have linked high-heeled shoe wear to knee osteoarthritis (a painful degenerative joint disease) as walking on high heels applies stress to the front and back of the knee. Other foot problems caused by wearing the popular style of shoe include metatarsaglia, thickening of the tissue around a nerve in the third and fourth toes called 'Morton's Neuroma', due to irritation and pressure placed on the ball of the foot (Anthony 2017). Anthony also reports on an increasingly popular trend for women with serious foot pain (caused from wearing ill-fitting fashionable high heels with pointy toes) called 'cosmetic toe modification' or 'Jimmy Choo fix' (Bryner 2008) — an invasive, surgical procedure involving the shaving down of the bones on the second or third toes.

[26] High-heeled shoes were worn in the late 19th century by male and female courtiers, the shoe designer attributed to popularising the high heel is French designer Andre Perugia in around the 1930's and it's at this time that the term "Stiletto" was coined ("Stiletto" is an Italian word for a small metal dagger). The stiletto heel came with the advent of technology using a supporting metal shaft or stem embedded into the heel, instead of wood or other, weaker materials that required a wide heel, enabling the stiletto to reach new heights in the years ahead of between 2.5cm and 25cm. The shoe went out if fashion in around the 1940's and there was a revival of the opulent heel style I the 1950's which is attributed to the designer Roger Vivier *(*Paslawsky, 2008). After their demise in the mid-late 1960s, high heels/stilettos were difficult to find until recently due to changes in the way heels were mass-produced.

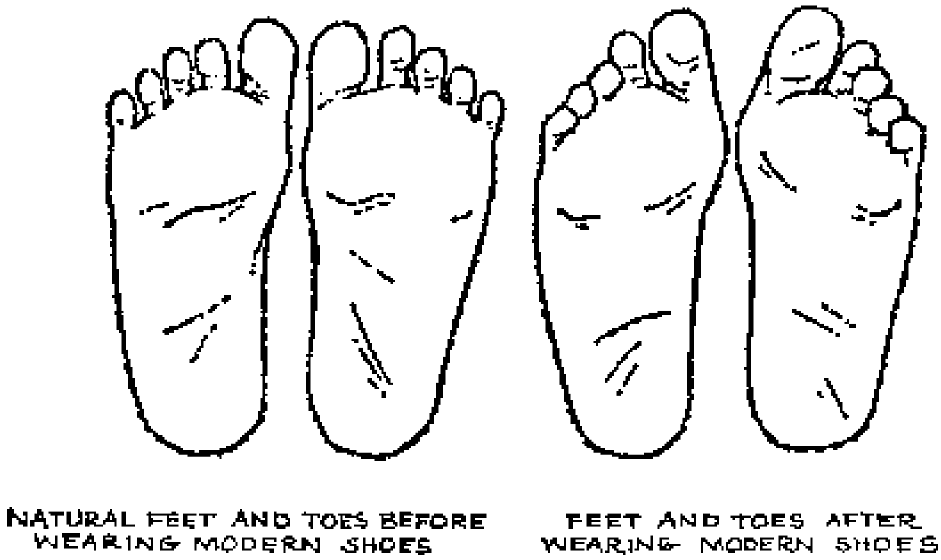

Figure 23. A 1961 *Illustration of the ills of modern feet*, from Simon J. Wikler, D.S.C., *Take Off Your Shoes and Walk* (Devin-Adair).

It’s also known that women sever their pinkie toes or use Botox injections to loosen up toe muscles, both procedures helping their feet slide into stiletto’s. These kinds of procedures are referred to as a ‘Cinderella type phenomenon’ by Dr. Angelo Volandes (2008) of Massachusetts General Hospital who comments "If you are born an envious stepsister with a wide foot, medicine can surgically enhance you into a Cinderella so that your newly trimmed foot fits a narrow glass slipper" (Bryner 2008, as seen in Anthony 2017, p. 35). It’s noted amongst academic and practicing traumatologists that it’s mostly women who have bunions[27] and undertake bunion surgery as high-heeled shoes and pointy toed shoes have mainly promoted the development of bunions.

To support Rudovsky’s idea of modern heeled shoes being ‘foot deformers’, the current creative director of Moschino, fashion designer Jeremy Scott, literally designed a pair of ‘sick’ high heels, through the representation of a bandaged foot with a protruding spiked heel, “signalling the very sickness of the feet through the effects of high-heeled shoe wear and the shoe’s agentic capacity, as a body prosthetic” (Lupton 1998, p. 144 as seen in Hockey 2013, p.

[27] A *bunion also known as hallux valgus*[27] and *hallux rigidus,* is a painful bony prominence that occurs in many individuals on the lateral aspect of the fifth metatarsal, “Hallux valgus is a structural foot deformity in which the angular deviation of the hallux is greater than 15 degrees toward the lesser toes with respect to the first metatarsal bone, and it appears as a medial bony enlargement of the first metatarsal head” (Alyssa B. Dufourr et al. 2014). Hallux rigidus or stiff big toe is arthritis of the big toe joint (*Colley 1887).* It is the most common arthritic condition of the foot and second only to hallux valgus (bunion) as a condition associated with the big toe.

22). Scott's work, entitled *Foot modifications*[28] (see Figure. 24), borrows materials from medical aesthetics and concepts informed by artist ORLAN's[29] plastic surgery performance artworks (Scott has proudly confessed this to his artist friend ORLAN). Scott connects art and design with ideas of medical necessity becoming a fashion accessory (Pullin 2011) thus, fetishizing the very notion of 'disabled high-heeled feet'.

Figure 24. *Foot Modifications* by Jeremy Scott, 1996.

ORLAN's performance-surgeries were titled *The Reincarnation of Saint-Orlan* and involved having her body surgically sculpted over ten different surgeries. The work challenges notions of female beauty. As ORLAN says, "My work is not a stand against cosmetic surgery, but against the standards of beauty, against the dictates of a dominant ideology that impresses itself more and more on feminine . . . flesh" (ORLAN cited in O'Bryan 1997/2005). ORLAN's operating

[28] *Foot Modifications* (1996) and was part of the exhibition *Body Extensions: How we extend our bodies,* Museum fuer Gestaltung, Lausanne, Switzerland, 2004. http://www.museum-gestaltung.ch/en/exhibitions/review/museum-bellerive/2000-2016/2004/body-extensions/

[29] On Orlan and the connection between performance art, fashion and cosmetic surgery see Victoria Duckett, "Beyond the Body: Orlan and the Material Morph," in *Meta-Morphing: Visual Transformation and the Culture of Quick Change,* ed. Vivian Sobchack (Minneapolis: University of Minnesota Press, 2000), 209–23. See also: *Penetrating layers of flesh: Carving in/out the bodies of Orlan and Medusa, Artaud and Marsyas*, Jill O'Bryan, Women & Performance: a journal of feminist theory Vol. 11 , Iss. 1,1999 / "Saint Orlan Faces Reincarnation" Jill O'Bryan, *Art Journal*, Vol. 56, No. 4, Performance Art: (Some) Theory and (Selected) Practice at the End of This Century (Winter, 1997), pp. 50-56 / Carnal Art: Orlan's Refacing, C. Jill O'Bryan, 2004, The University of Minnesota Press / http://www.orlan.eu/.

table became her baroque theatre. Designers, such as Paco Rabanne and Issey Miyake made costumes and shoes for ORLAN to wear during the surgery performance with poetry being read and music played while she lay fully conscious. The use of high-heeled shoes together with the cross in her artwork, (see Figure. 25 and Figure. 26) provoke her attitudes towards religion and symbols in society.

> Religion is always against women, and Christian art wants us to not touch bodies, to choose between good and evil. But all my work is about good and evil. So for me God isn't a solution for my life, or for my work (ORLAN 2009).

Figure 25. *Successful Surgery, 1991,* 4th Surgery-Performance from the series *The Reincarnation of Saint ORLAN*, by ORLAN.

Figure 26. Artworks from *Successful Surgery, 1991,* 4th Surgery-Performance from the series *The Reincarnation of Saint ORLAN*, by ORLAN.

High-heels disable feet, but they also disable the walker through their 'unwalkability', something that has been a subject of a collection of shoes by Prada in 2008 where the shoes were deliberately designed to miss the middle part of the shoe, with the models' feet only having the heel and front parts of the shoe to rely on, deliberately disabling the women who wore them. Given the performativity and torturous impracticalities of the extreme high-heeled shoes, five models fell over during the Prada Spring Ready-to-wear 2008 (see Figure. 27).

Figure 27. Prada Spring Ready-to-wear, 2008.

Despite models falling over and widespread news about the perils of high-heeled shoe wear, instead of rejecting the extreme heels, many women cannot seem to get enough of the 'unwalkable' high heels. The Wall Street Journal (2008) reported that "Women fall head over heels for shoe makers" and that 'uber-heels' (3 inches or higher) represent 25% of all women's fashion footwear sold at shoe retail chains, with moderate heels (1 1/2 inches to 2 7/8 inches) falling from 34% to 26% in 2006. They go on to write that 'supersized heels' and platforms (5] to 7 inches) are becoming more common and are the highest heels seen at the commercial level.

2.4.2 Shoe prosthetics: Cheetah women and spiked heroines

Fashionable, prosthetic high heels and appendages can also be used to physically and metaphorically modify the feet and also challenge perceptions of disability. World-class Paralympic athlete Aimee Mullins, famously said at a TED talk, "A prosthetic limb doesn't represent the need to replace loss anymore. It can stand as a symbol that the wearer has the power to create whatever it is they want to create" (Mullins, 2009). During her talk, Mullins also indicates that her legs can be wearable sculptures and provides examples of her wearing such pieces, including prosthetic hand carved ash wood boots from fashion designer Alexander McQueen's 1999 show *No. 13* and glass high-heeled shoe prosthetics from Matthew Barney's *The Cremaster Cycle* project[30]. Mullins also describes her experience transforming into the symbol and myth laden 'Cheetah Woman Queen' character in Barneys' film explaining "the Cheetah legs hurt in the same way that high heels hurt until you get used to it. I'm used to it". This interestingly illustrates that prosthetics and high-heeled shoe prosthetics, like conventional heeled shoes, also carry a price for looking fashionable.

Technologies such as 3D printing and computer-aided design have informed a new world of design possibilities for customizable artificial limbs. Bionic pop artist Viktoria Modesta makes sculptural prosthetics limbs a central part of her performance art. Modesta's prosthetics are critical fashion statements and illustrate how her body is an extension of her performance and art[31]. Her prosthetics exploit technology for visual and sometimes audio effect, wearing different prosthesis depending on the context. For example, in a scene from the music video *Prototype* (Modesta 2014), moths flutter around her electric prosthesis as it lights up a dark room. In another scene, she catwalks, dressed like a ballerina on puppet strings across the screen with a jet-black cone that sharpens to a spike (see Figure. 28). Modesta worked with Sophie De OIiveira Barata's *Alternative limb project*, to develop the well-known *Spike*. The Spikes' clean triangular line from the floor to her natural knee, reminds one of the visual look of the leg and foot afforded through Chinese foot binding or ballet pointe shoes and yet, Modesta's spike is also politically charged and powerful looking. She takes on the guise of a ballet dancer and yet literally smashes the un-free nature of ballet, every time she smashes the point of the spike on the glass ground in *Prototype*. Thus emancipating herself from the preconceptions of disability, using ballet as a metaphor for liberation.

[30] The Cremaster Cycle is a series of five feature length films shot between 1994-2002 together with related sculptures, photographs, drawings, and artist's books, created by American visual artist and filmmaker Matthew Barney.

[31] Modesta's prosthetic spike was exhibited in the wearable technology exhibition "#techstyle", Museum of Fine Arts, Boston, 2016 http://www.mfa.org/news/techstyle. The spike and other prosthesis appeared as fashion styling elements in her music video *Prototype* https://www.youtube.com/watch?v=jA8inmHhx8c.

Figure 28. Viktoria Modesta wearing *The Spike* made with,
Sophie De OIiveira Barata and Kaos Art for *The Alternative limb project* 2014.

2.4.3 Ballet shoes: En Pointe to pain

The first nineteenth-century pointe shoe was worn by dancer Marie Taglioni, during her performance in *La Sylphide in 1832*[32]. A curiosity is that she was not using the pointe shoes as we know them today, but she used to dance with normal soft ballet slippers (constructed of either cloth or leather) with reinforcements in the block of the shoes. The sides of the shoe and the tips of the toe were darned by the dancers themselves in order to provide a small amount of support, but the essential form was unaltered. The resulting slipper enabled the dancer "to rise to her toes for just a few moments—enough time to produce a sense of otherworldly

[32] Taglioni the dancer went en pointe for a few seconds, using it as a technical trick, impressing audiences by her weightlessness and looking like she was flying or floating above the ground, later the technique was perfected and is now an integral part of classical ballet techniques.

weightlessness but not to perform any complex technical feats" (Laemmli 2015). One could say it was an acrobatic trick to surprise audiences.

Ballet shoes then went on to be produced in standardised sizes, with Capezio (1929) patenting the first technology. A brief anatomy of a contemporary ballet shoe includes a small box made from fabric, cardboard, and paper that is hardened by glue and placed in the tip of the shoe so that the dancer can balance her entire weight on her toes. Dancers need to train for years to ensure that their ankles and legs can withstand the strain of balancing their entire weight on their toes and need to exercise an unprecedented amount of control over the ways in which they interact with their shoes. *Pointework* is a dramatic moment of balance.

Some more romantic centric ballerinas, try to create the magical otherworldliness the illusion of flight or levitating above the ground, by concealing their shoes, often using makeup to match the colour of their pointes to that of their legs. As such, in photographs or paintings, ballerinas have frequently requested that their pointe shoes be retouched so that the already minimally blocked toes whittled down to near-nothingness—so that the dancer looked as if she were rising to the sky entirely of her own will. Similarly, ballet choreographer George Balanchine believed that "the foot in the pointe shoe was most attractive when it tapered when viewed from the front, a look enhanced by the presence of a bunion on the big toe's first joint. Balanchine urged dancers to consciously shape their body in line with the pointe shoe" (Laemmli 2015, p. 14).

While dancing on pointe is aesthetically pleasing, it can damage the feet of any dancer and is especially harmful for professional dancers. Ironically, the serene faces of the dances, together with their elegant pink silk shoes actually conceal a number of foot injuries ranging from black nails, purpling flesh and growths such as corns and blisters (John 2006). In his 1973 book *Dance Is a Contact Sport*, journalist Joseph Mazo provides a further perspective on the physical effects of pointe shoes:

> Dancers have voluntarily altered the course of evolution, and that practice invariably leads to trouble. . . . Human toes were not designed to stand on. . . . When an organism is as much modified in structure and purpose as a dancer's body, it becomes dangerously fragile. When breeders began trying to produce longer and longer dachshunds, the dachshunds started to die of broken backs—their spines were weakened by over-elongation.[33]

[33] As seen in Technology and Culture, Volume 56, Number 1, January 2015, pp. 1-27 by: Whitney E. Laemmli

Sports related injuries caused during dancing in ballet pointe shoes occur mainly to the forefoot but can also include injury of the long medial flexors due to the repetitive stresses placed on the tendon when dancing *en pointe* (Lo et al. 2001).

As reported in the BBC documentary film *The Struggle of the Swan* (1987) narrator Debbie Arnold describes, "the main tools of a dancer are basically, feet". The dancers featured in the film describe that after wearing pointe shoes, their feet squish into the shape of the shoe (especially after heavy rehearsals) and corns regularly form between their toes. Further details on wearing pointe shoes is provided in the documentary:

> Layers of hessian and glue are built up into a block so that the dancer can stand, unnaturally, on the points of her toes. The materials are water-soluble and soak up the sweat of the dancer's foot. The block breaks down slightly on impact with the floor into a crystalline powder, forming a cushion shaped to the dancer's foot. The outside of the toe is hammered into a platform shape as required by the dancer. However, they are not a natural foot shape. For example, there is no left or right. They are made for style and line, not for comfort (*The Struggles of the Swan* 1987).

The documentary goes on to describe many of the dancers experiencing so much pain through durational wear of pointe shoes and dancing *en pointe,* effecting other areas of their feet and bodies with many receiving cortisone shots in the heel to supress the pain and enable them to dance on.

Not surprisingly then, female ballet dancers must have a high tolerance for pain with ongoing fear of injuries being universal amongst dancers (Kelman 2000). Foot injuries are the most common injuries with female ballet dancers, as toe dancing or en pointe results in "non-physiologic weight bearing that exaggerates the metatarsal arch and can lead to distorted posture" (Ostwald 1994). It is obvious from the research that pointe shoes cause deformity of the feet and other postural health problems for dancers, which also has damaging psychological effects on their performance and shortens their careers (Kelman 2000).

Given their torturous effects, one can draw parallels between high heels and ballet pointe shoes. Pointe shoes are meant to elevate the dancer, metaphorically speaking to help take the body from 'low to high' to get closer to 'perfectly pure heaven' (Bataille, 1985). Dancing on pointe and wearing heeled shoes also aids in creating the illusion of longer more slender

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extra foot note: also interesting to read about regarding pointe shoes Higgins, Michelle. "The Ballet Shoe Gets a Makeover, but Few Yet See the Pointe." *Wall Street Journal*, 18 August 1998.

legs that seem never ending. The notion of the never-ending leg created by a pointe shoe or high-heeled shoe, is also reminiscent of the bound feet of Chinese women, which at times looked like the women didn't have feet at all.

2.4.4 Shoe tools: the functional specialisation of shoes

Oakley (1952, p. 1) describes a human being as a "social animal distinguished by 'culture': by the ability to make tools and communicate ideas. The employment of tools appears to be his/her chief biological characteristic, for considered functionally they are detachable extensions of the forelimb". For Dilley et al., footwear enables us to carry out "culturally-specific competencies, such as classical ballet and climbing" (2013, p. 5). Further to that, "shoes can produce or 'finish the body' profoundly altering posture and gait, depending on whether they are high heels, walking boots or flip flops" (2013, p. 5).

There is a rich history of shoe-based tools or the functional specialisation of shoes that enable the feet to perform specific tasks and that can alter the body and its movements. For example, moon boots were specifically designed for the wear and tear of the moon and assisted Neil Armstrong to perform that first step for humankind. The $30,000 USD a pair moon boots needed to "tolerate temperatures from minus 212°c to plus 177°c, resist micrometeoroids (at 72,000 km an hour, even dust is destructive) hold up the rocky surface of the moon, yet comfortably allow the wearer to hike back….to the landing module" (Newman 2006). ILC Dover, Delaware, a manufacturer of engineered products employing high-performance flexible materials to aerospace agencies such as NASA, is working on the latest in space footwear, the M2 Trekker, which is constructed in 3 parts featuring an inner pressure bladder, a middle structural layer, and a protective cover (Newman 2006). The boots are made of materials like nomex, aluminized mylar, nylon, spandex and teflon that lock together to fit varying foot sizes.

Figure 29. The *Haptic boots* prototype being tested in the MIT Mann Vehicle Lab, 2017.

Future space exploration of planets like Mars, will involve extra-vehicular activities (EVA), which will require walking around on foreign planetary surfaces with boots (material tools for the feet) (Gibson et al., 2017). Alison Gibson et al. from MIT's Mann Vehicle Lab are developing the next generation of haptic astronaut boots for Mars[34]. The vibrotactile boots (see Figure. 29) contain an ultrasonic rangefinder and proximity sensor to help astronauts navigate (providing tactile queues to the big toes of the feet). The new boot has built-in sensors and tiny haptic motors, whose vibrations (which jump from low to high intensity) can guide the wearer around or over obstacles, acting as a sort of decision-making assist system. The space footwear also looks like a prototype in progress, which is also an aesthetic, unfinished. This may be important in the context of an aeronautical scientific experiments, for, if the test shoes looked too 'finished' like a product, they may not be as convincing to the scientific community (see Figure. 30).

[34] To see experiments with *Haptic boots* visit: https://www.youtube.com/watch?v=ri0Qc3I99JU&feature=youtu.be

Figure 30. The *Haptic boots* prototype being tested to carry out human factors research at the Mars Desert Research Station, 2017 (a full-scale analogue facility in Utah supporting Earth-based research in pursuit of the technology, operations, and science required for human space exploration).

2.5 Shoes as stage, on stage

If our bodies are the one thing we control exclusively (Baudrillard 1970) and clothing and footwear is our expression of self (Lurie 1981), clothing and shoes can amplify a person's expressivity further to symbolise a character, as can shoes (Barthelemy 2001). Some authors argue that shoes have the power to transform the self, being worn as a type of staging for role playing (Mazza 1994). Dilley, for example, positions 'shoes as stage' giving individuals tools to play certain roles at 'special occasions' (Dilley et al. 2013) which points to shoes in effect being components of masquerade, with narratives being inscribed onto shoes. Benstock and Ferriss explore the cultural significance of shoes noting that "Feet are not neutral parts of the body, and our choice of shoes is a potent expression of the self" (2001, p. 52).

Two studies conducted by Belk (2003) in 1990 and 2000 in Salt Lake City, Utah with a wide-ranging group of people aged between 16 and 74 years old show how shoes can facilitate a transformative experience:

> Shoes are seen as highly significant articles of clothing that are regarded as expressing the wearer's personality and perhaps as even capable of magically transforming them into beautiful, handsome, happy, confident or heroic people… footwear is an extension and expression of themselves…. whether self-image is changed by shoes because of actual feedback from others or because of the reactions we have learned to expect from wearing certain shoes in certain situations, donning shoes can be a self-transformative experience (Belk, 2003 pp. 27, 30).

Kate Moss wearing *The E-shoe* (see Figure. 31) is a good example of shoes as stage. Her naked body is presented on shoes that are not just shoes —they are a unique pair of bespoke E-Shoes, a digital, wearable guitar instrument by Chicks on Speed. I developed the shoes in collaboration with Max Kibardin to make them appear like a finished shiny fashion product that could work both on stage and in a fashion magazine. The photo by Mario Testino depicts the shoe juxtaposed against the naked body of Moss. This composition implies that clothing could not compete with the shoes and therefore Moss simply went naked, which in turn placed further attention on the shoes. Another reading could be that her bare body was a form of protest, as in the tradition of feminist performance art, where "women performance artists expose their bodies to reclaim them to assert their own pleasure and sexuality, thus denying the fetishizing pursuit" (Forte 1990, p. 262). Thus the depiction of naked Moss, staged on a pair of skyscraper like plateau shoes grant her control over the magazine readers' gaze. The shoes temporarily transform her into something resembling a "super-individual" (Coleridge 1990, p. 435) or a cyborg adorned with prosthetics to extend her human form.

Figure 31. Kate Moss wearing *The E-Shoe* by Chicks on Speed (Alexandra Murray-Leslie) and Max Kibardin, Photo by Mario Testino, Brazilian Vogue, September Issue, 2012.

These aforementioned examples describe footwear-evoking individualism in the recently formed experimental area of 'shoe theory'[36], an area of fashion theory, within the broader field material culture. Shoe theory explores shoes in general (not specifically shoes on stage in performance), therefore, an examination of footwear in performance art, specifically technology-enhanced footwear is warranted.

Technology-enhanced footwear in performance gives shoes a dual purpose, that of a fashionable styling object and an expressive musical instrument. It also embodies Koether's idea of 'secondarity' (permitting things to spread out) as it enables shoes to shift characteristically in all directions without cultural obligation (Koether 1986). Secodarity is an interesting aspect to this research and also aligns to ideas expressed in the field of New Interfaces for Musical Expression (NIME), in which musical instruments are relevant to performance for both physically aesthetic and musical reasons (Johnston and Murray-Leslie 2017). Performing the role of the shoes is something that can be built into the initial design of the shoes, which will be unpacked later in thesis.

2.5.1 The look of music: Shoe semiotics and style in pop music

David Bowie is well known for his multidisciplinary approach to the visual presentation of his music. Importance was placed on the process of making, everything was interconnected and part of a 'gesamtkunstwerk'. Gesamtkunstwerk is an all-encompassing artwork or 'total work of art', a term previously used to describe the work of Albert Loos and Richard Wagner (Roberts 2006) and my own group Chicks on Speed. It emerges within the Bauhaus school and manifests itself in the performances of Andy Warhol, Walt Disney theme parks and cyberspace (Smith 2007).

Bowie's artistry and interconnected, holistic approach stems from his experiences in various Arts Labs[37] of the late 1960s which nurtured practicing in multimedia installations and

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[36] *Über Schuhe: Zur Geschichte und Theorie der Fußbekleidung* by Anna-Brigitte Schlittler and Katharina Tietze, 2016 is possibly one of the first books that declare a theory of shoes within the larger domain of fashion theory. Schlittler and Tietz portray shoes as being much more than functional and fashionable foot coverings and being an integral part of material culture. Within their historical reading, they highlight social and cultural changes and schisms associated with shoes. The implications of technology-enhanced footwear is not presented in this context of shoe theory inside fashion theory and requires its own reading, something that is missing in current literature.

[37] The Arts Lab was an alternative arts centre, founded in 1967 by Jim Haynes at 182 Drury Lane, London. Although only active for two years, it was influential in inspiring many similar centres in the UK, continental Europe and Australia, including the expanded Institute of Contemporary Arts (ICA) in London. https://en.wikipedia.org/wiki/Arts_Lab.

cross-disciplinary artworks with the members of the labs and involved "experimenting in lighting, stage management, theatre, filmmaking, and music" (Marsh 2013, cited in Buckley 2014, p. 38). Buckley describes Bowie's creative output as:

> the product of an aesthetic disposition toward problem solving. Creativity depends not so much on a concept of genius as on a studied approach to readying materials (fabric, sound, words, paint) and making objects (songs, clothes, lyrics, paintings) for show and performance (2014, p. 654).

Bowie wrote the song *Let's Dance* in 1983 and the music video was shot in a bar in small town Carinda in outback New South Wales, Australia. The video features an Aboriginal couple[38] (two dance students, Terry Roberts and Joelene King). In one scene, the couple are walking through the desert and find a pair of mystical shiny, red, patent leather pumps (see Figure. 32) on a desert mountain (the pumps were not hand crafted like many of his other stage costumes, but ready-mades to represent a specific stereotypical woman who would wear such shoes). When the woman puts on the shoes, she instantly learns to dance. There are several scenes in the video depicting their struggle in urban Sydney including washing roads by hand and pulling a giant drill down a highway (slave-like with a rope around his neck and juxtaposed by the couple dancing freely in an outback pub). The red shoes in the video have a transformative power to make the girl dance western style, instantly becoming a part of colonial culture. As Trammell (2016) describes, once she wears the red shoes the couple is:

> visiting museums, enjoying candlelit dinners and casually dropping credit cards, drunk on modernity and consumerism. During a stroll through an arcade of shops, the couple spots the same pair of red pumps for sale in a window display, their personal key to joy and freedom. They toss away the magic kicks in revulsion, stomping them into the dust and return to the mountains, taking one final look at the city they've left behind (Trammell, 2016).

Thus the red shoes deliver a psychological autonomy as well as a political status in the video to make a 'very simple, very direct' statement against racism but also a very direct statement about integration of one culture with another. As Bowie describes, "The red shoes are a found symbol.

[38] Bowie told *Rolling Stone* magazine at the time that he wanted to make a political statement with the clip: one that illustrated the harsh realities of life for indigenous Australians, http://www.brisbanetimes.com.au/entertainment/music/dancing-to-bowies-tune-still-resonates-30-years-on-20130505-2j12i.html.

They are the simplicity of the capitalist society and sort of striving for success" (Pegg 2011 p. 694). The song's lyrics, "Put on your red shoes and dance the blues" are obviously a reference to the 1948 movie *The Red Shoes*, where a dancer performs in a ballet of that name. The idea is that the red shoes make you dance recalling the original fairy-tale *The Red Shoes* by Hans Christian Andersen.

Figure 32. *Let's Dance* music video by David Bowie, 1983.

The Bowie video, like fairy tales, uses shoes as a metaphor to express their transformative power to transport one to another place, a 'better' place which I suggest acts as a type of epiphany - the shoes offer the wearer to improve one's life, or attain one's dreams, transporting one to another location or creating an altered state of freedom or escapism. For example, Cinderella's glass slippers or Dorothy's ruby red shoes in *The Wonderful Wizard of OZ* (Baum 1900), signify transformation from one place to another. Other fairy tales where shoes were used to create an epiphany include *The Shoes That Were Danced to Pieces* (Brothers Grimm 1812), and Hans Christian Anderson's *The Red Shoes* (1845).

> [In] *The Goloshes of Fortune* another tale by Hans Christian Andersen… the galoshes provide for an escape to a more exciting time, but as with Andersen's other tales, there is a dark side to this fantasy, and the interesting life provided by the galoshes ends up being dangerous indeed. Like *The Wizard of Oz* another story featuring a magical pair of shoes, one lesson to be learned is that one should not wish for a different life than one has and should be thankful for what one already has (DeMello 2009, P. 118).

If one compares this to the red shoes in Bowie's video, they too transport the aboriginal girl to a European Australian life that looks like fun from the outside, but with the scenes of slavery pictured in-between, of her washing the road on her hands and knees, it is clear, that there is also a dark side to putting on the red shoes. The act of dancing into western imperial culture and forgetting indigenous heritage and history such as the atrocities of the stolen generation illustrates that footwear can also transmit deeper more serious political ideas within a seemingly fun medium of the pop culture music video.

Dilley et al. (2014) explore themes around high-heeled shoe wear for special occasions and notions of associated temporality, which is interesting in the case of this research around shoes for performance, as performance is a temporary event which usually involves role playing, supporting notions of 'dressing up' for stage (Dilley et al. 2014, p. 1). This can be compared to discourses around choices of dress as constituting identification of the wearer (2014, Dilley et al.) or being able "to negotiate meaning and position" (Gleeson and Frith, cited in Dilley et al. 2014, p. 1). To support this concept of the constitution of identification through clothing and shoes, in an interview with Bowie on the BBC *Newsnight* current affairs program with Jeremy Paxman in 1999, Bowie declares that he was never comfortable on stage, but the costumes and role playing, altered this sense of identity by the adoption of a fashion look which brings confidence on stage

For guitarist Viv Albertine[39], a pair of shoes, worn with a specific outfit on stage, embody a meaning far greater than just fashion, but an attitude reflecting a new subcultural generation or a zeitgeist (Hebdige 1977). In her memoirs, Albertine (2014) explains the difficulties manifesting a new personal style on stage, not just through fashionable outfits for stage but also through her instrument, which she describes as a difficult concept. Albertine asks herself in 1975, "What would I look like if I was a guitar sound?". It is this idea of individual style expressed through one's look and musical instrument (on stage tools for creative audio visual expression) that is interesting and unique to this research. If "shoes are an accessory to speech and presence" (Emberly 2001, p. 35), and if shoes are embedded with technology, they could make an important impact on the way bands express themselves by using 'fashion acoustics'. Albertine (2014) introduces the importance of putting a 'look'[40] together for stage performance, which could be interpreted as creating a temporary identity for an occasion

[39] Albertine was a founding member of the all-girl band The Slits, a group that existed from 1976 to 1981.

[40] A "Look" is like a "style" in fashionable dress. Polhemus (1994, p. 14) describes 'styletribes' in his book *Street Style* as a distinct cultural segment that generates a distinctive style of dress and decoration.

(Dilley et al. 2014). The style Albertine was attempting to create in 1976, she called a “sartorial ensemble” or “Pippi Longstocking meets Barbarella meets juvenile delinquent” (2014 p. 112).

This concept of putting a style together and naming it like a character, became an integral part of a focus group study between myself, Sam Ferguson and shoe designer Max Kibardin (Max Kibardin studio, Milan, 18th June 2014), collaborators on the *Computer Enhanced Footwear* project. Outcomes of the focus group led us to agree that design methods should include:

- working in a larger cross-disciplinary group
- seeing the visual body of the performer within the frame of the complete stage identity and setting
- the ‘total work of art’ or ‘gesamtkunstwerk’ (by applying ‘gesamtkunstwerk thinking’ when designing *computer enhanced footwear* for stage, the entire ‘look’ or styling of the physical scenario is considered).

2.5.2 Propology: the theatricalisation of high-heeled shoes

A critical examination of a theatricalised ready-made shoe as musical instrument can be understood in terms of Sofer’s thoughts on props:

> The prop is best understood as embodying a volatile “temporal contract” established between actor and spectator for the duration of performance. Although the spectator is always free to take up a range of understandings of the prop’s meaning, the prop’s very fluidity as a theatrical sign encourages playwrights to use it as a concrete tool to subvert the symbolism previously embodied by the object it represents (Sofer 2003, pp. ix-x).

Sofer’s idea of ‘propology’ examines the performance of props and stage objects through complex semiotics and phenomenological factors, by focusing on props as the temporal signs of social meaning (Sofer 2003). He argues that while props are tied to an object’s symbology, theatre can appropriate the symbolism for its own ends and then revise (or attempt to revise) the meaning for its audiences. As I claim in my introduction, physical, aesthetic and spatial dimensions tend to vanish when a musical instrument is considered primarily as a symbol for music making (as in traditional classical musical instruments, primarily there to perform sound) remaining a one-dimensional sensory image). In the case of musical instrument shoes, the symbolism of the high heel is appropriated and transformed into a form of musical expression. However, it is important that the shoe is recognisable and is not just some sculptural shaped foot appendage, so that the "theatrical form implicitly undermines its doctrinal message" (Sofer 2003 p. ix).

Sofer, sees props as having temporal and spatial significance, that are not just symbols but tools of expressions. Such notions support why the high-heeled shoe guitar is not merely used to "'prop up' conventional symbolism" (Sofer 2003, p. 11). As Karen Freeze notes, theatrical "artefacts are made explicitly to express an idea" (Freeze 2012 cited in Laemmli 2015, p. 5) and therefore present a particularly useful medium to express the vision of its creator.

2.5.3 Costuming the foot

> [Dress (including footwear)] is simultaneously an intimate experience of the body and a public presentation of it… it is the interface between the individual and social world, the meeting-place of the private and the public. It is a suit of armour or a shell, for, like the crab, the 'raw' human body is distinguished by its characteristic of being somehow unfinished, unpeeled, vulnerable and incomplete. But it is also a costume for a role, and for the dramatisation of identity" (Entwistle and Wilson 2001).

Feet adorned or costumed as the object of visual and performance art have the power to explore and express a specific idea. As such, various artists have used shoes as the central subject of their artworks, some of which are explored below.[41]

Italian artist Giacomo Balla was convinced that clothes could physically influence the wearer. As a key proponent of Futurism, Balla's futurist manifesto ideas were creatively embodied into his artwork, which included accessories such as shoes (see Figure. 33). In his 1920 manifesto for futuristic women's clothing he creates a direct connection between futurist painting, fashion and shoes (Stern 1992).

[41] See *The Historialist of shoes and shoemakers* for a list of prominent paintings and sculptures featuring shoes, http://www.thehistorialist.com/p/shoes-and-art.html.

Figure 33. Two-Tone Men's Shoes by Giacomo Balla, ca. 1916-18.

Vanessa Beecroft, has created choreographed lens based works featuring women and shoes, which were presented as large scale, live performance art works. She refers to the heels in her performances as 'pedestals' (Johnstone 2005), which have been loaned or specially fabricated by fashion designers such as Miuccia Prada, Tom Ford, Helmut Lang, Dolce and Gabbana, and Manolo Blahnik.

Her performance art works deal with questions around identity politics, gender, sexism, body art and voyeurism. Beecroft's performances featured naked, female models, standing ridged, silent and persevering while wearing fashionable (and uncomfortable) high-heeled shoes (see Figure. 34 and Figure. 35). As Kellein describes, "These women, mainly unclothed, similar, unified through details like hair colour, or identical shoes, stand motionless, unapproachable and regimented in the space while viewers watch them" (Kellein, 2014, dust jacket).

[Production Note: This figure is not included in this digital copy due to copyright restrictions.]

Figure 34. *VB35.308.MST* by Vanessa Beecroft, 1998.

[Production Note: This figure is not included in this digital copy due to copyright restrictions.]

Figure 35. *VB 43.018* by Vanessa Beecroft, 2000.

Given the discomfort of standing in heels for prolonged periods of time, during the course of the performances, it is not uncommon for some models to faint, end up on the floor and be carried out at the end. Art historian Maria Elena Buszek comments on the ambivalence presented in Beecroft's work which is "the result of a culture that has both internalised feminist goals more than any generation that preceded it, and chafes against what it perceives as feminism's restraints" (Buszek cited in Johnstone 2005). Perhaps the torture they endure in silence can be compared to women's durational use of high-heeled shoes (signs of mass uniform, acceptable femininity) and their torturous effects on the feet.

Performance artist Marina Abramovic has created numerous iterations of *Crystal Shoes for Departure* (see Figure. 36) a piece which offers to transport the wearer into an altered state of consciousness (Hiller & Fisher 2010). Abramovic includes written instructions in the work, which function almost as a hypnotic suggestion: "With naked feet enter the shoes. Eyes closed. Motionless. Depart. Duration: limitless Material: amethyst" (Abramovic 2000). The work creates it's meaning through physical interaction, the feelings and imaginations of the audience who put on the crystal shoes, and the re-enacting of states of mind suggested by the artist (Hiller & Fisher 2010). Interestingly, the theme of shoes providing altered states of consciousness: reverie, dreams, trance, hallucination, spirituality, visions and psychological escapes from the present context were also explored in *The Wizard of OZ* and David Bowie's *Let's dance*. Confirming that shoes can be aspirational, even fantastical – and can project an image not just of who we are, but who we want to be (Persson 2015).

Figure 36. Marina Abramovich wearing *Crystal Shoes for Departure*, photo by Ruven Afanador, 2016.

The *Surveillance Shoe* by Jill Magid (see Figure. 37) is a hybridization of surveillance hardware and a pair of existing high-heeled shoes. A CCD surveillance camera with infrared technology is built into the shoe's design. Due to the fixed position of the camera to the shoe, the leg remains bound within the frame. While the leg appears stable like architecture, the actual architecture becomes mobile (Magid 2000). It is the performance of the shoe's surveillance that creates the resulting narrative photographic works. Through her performance-based practice of the surveillance shoe, Magid explores the emotional, philosophical and legal tensions between the individual and 'protective' institutions, such as intelligence agencies or the police. It is this 'dialogue' between a political act and humorous, almost absurd 'wearable' art object that I find interesting.

Figure 37. *Surveillance Shoe* by Jill Magid. Shoe: High heels, IR surveillance camera, battery pack, wireless transmitter in shoe sole. Video: B/W footage produced by 6 min. 2000.

2.6 Sound producing shoes

Various cultures have produced shoes to facilitate sound and music. Wearing these shoes became a form of creative expression, social status, special occasion and liberation and also informed the development of new dancing styles.

2.6.1 The hand's domination of musical instruments

> I see the hand as a part of the brain, not as a lower instrument of the brain. Of course, you can see a hand as a transmitter and sensor, but in the consciousness of the performance, the hand is the brain (Krefeld, V. & Waisvisz 1990, pp. 28-33)

There is a rich tradition of glove-based technology for performance including; Michel Waisvisz's *The Hands* (1984), Laeticia Sonami's *Lady Glove*[42] (made in 1991 and upgraded in 1994) and Imogen Heap's *Sound Grasp* (Mitchell & Heap 2011) and *Mi.Mu* gloves[43], all of which are particularly relevant to this research in that they use physical prototyping and sound mapping to extend the fundamental functionality of the hands.

Michel Waisvisz, was the artistic director of STEIM (Studio for Electro Instrumental Music) from 1981. He developed and performed with *The Hands,* which was inspired by Musical Instrument Digital Interfaces. As the artist explains, "MIDI suddenly allowed me to think of mini-keyboards, fitted to my hands and littered with various movement sensors to translate hand, arm and finger movements immediately into sounds" (Waisvisz 2005).

Glove-based research was originally developed for virtual environments (Jorda 2005) and health applications as most gestural language is based in hand movement. There are also terms, which refer specifically to hand language and expression:

> Chirologia[44]: or the naturall language of the hand. Composed of the speaking motions, and discoursing gestures thereof. Whereunto is added Chironomia: or, the art of manuall rhetoricke. Consisting of the naturall expressions, digested by art in the hand, as the chiefest instrument of eloquence (Bulwer 1644/2003, p. 5).

These examples demonstrate that hand glove-based instruments have received quite a lot of research and industry attention as compared to foot-based instruments. Therefore, there is great space for developing aesthetic shoe-based musical instruments and taxonomies for foot audiovisual expressivity. Furthermore, basing my research on shoes facilities a stronger link to the areas of fashion and costume, as more people wear shoe-based fashionable costumes than gloves.

2.6.2. Kipcaps, click clacks and clogging

During the Ottoman Empire, women of high-status (and some men) wore high wooden clog sandals referred to as 'kipkaps', 'kubkubs', or 'qabqabs' (Demello, 2009). "These shoes were

[42] More information about Laeticia Sonami's *Lady Glove* and her artistic practice making and composing with digital musical intruments:: http://sonami.net/ladys-glove/

[43] https://mimugloves.com/story/

[44] *Chirologia or, the art of manual rhetoric* is a compendium of manual hand gestures used in speaking, explaining their meaning and use, the hand shapes and gestures described in Chirologia are still used in British Sign Language today (http://library.uthscsa.edu/2014/05/anthropometamorphosis-man-transformd-or-the-artificiall-changling).

known for the distinctive sound that they made while walking, and from which the name is derived. While women primarily wore stilted sandals, men wore simple versions while in the bath house" (DeMello 2003, p. 208).

Another example of a wooden sound-producing shoe is the *geta* from Japan, which produced a distinctive "click clack" sound when they were worn in the streets. Additionally, "pokkuri geta are high hollow-soled *geta* with one large platform with bells included inside. They are worn by girls on special occasions and make a sound like 'pok-kuri' when worn" (DeMello 2009, p. 181).

During the industrial revolution, the style of dance known as 'clogging' (which originated from the Cherokee's social dances in the Appalachian Mountains), involved wooden-soled shoes stomping on the ground to the tune of music. This style of dance began in the factories when workers would tap their feet on the ground whilst working; and is often considered the first form of street dance because it evolved in urban environments. In addition, it was from clogging, that contemporary tap dance also evolved.

2.6.3 Tap Shoes: Dancing as music

Tap shoes, also known as 'character shoes', are perhaps the best-known popular example of using shoes to make sound. As Seibert writes, "tap is both dancing to music and dancing as music" (Seibert 2015, book abstract). Tap shoes blend dance with percussive sound to make a distinct art form with its own rich and complex range of practice and history.

Tap dancing originated from the dances of African-American slaves during the seventeenth and eighteenth centuries (DeMello 2009). Given their culture was highly musical, "dance and music propel[led] each other" (DeFrantz 2002, p. 42) and the slaves practiced dance on the ships going from Africa to Northern America. For them, dance was a form of protest — a way to keep their art and culture alive. Their bare feet acted as the percussive expressive element, a form of recreation and relief to their oppressed situation. It was "their greatest spiritual and political resource, enabling them to recall the traditional African community and to include all Africans in their conception of being Africans in America" (DeFrantz 2002, p. 44). The dances were many and varied. Some dances were extremely energetic with dancers climaxing to a state of possession. According to DeFrantz (2002), styles included shuffling, *The Shout* (which involved the thud of the feet, along with 'jerking' and 'hitching' motions) and *The*

Ring Shout, where dancers danced collectively in a circle. As well as tap dancing, other styles of dance including work songs, spirituals, minstrel performances, vaudeville; and later blues and jazz (Bosman 2012) originated from this rich history of African diaspora culture in America.

Figure 38. Above, various styles of Tap Shoes. Below: Tap shoe heels: teletone (left) has a recessed cavity and is lighter in weight, this tap allows the dancer to achieve a higher-pitched tone compared to a solid tap; duotone (middle) both are trademarked brand names by Capezio dance shoes; and supertone (right).

The first tap shoes had wooden soles (and were believed to have originated in the first minstrel shows around mid 1850) and were later leather and equipped with metal plates called taps, which started to be worn around the 1930's. The taps are usually made from lightweight aluminium, or sometimes zinc and silicon alloy. The taps are attached securely to the toes and heels of shoes using three screws that are driven into a 'soundboard' – a thin fibreboard integrated into the sole, which also allows for a slight tonal shift produced by having the taps pressed next to the fibreboard. The size, shape, and thickness of the taps influence their weight, tone, and the flexibility of the shoe, heavier taps on the heel will affect the sound quality delivering a more bass heavy sound, while a large heel hinders dancers from getting up on their toes. Soles, which are made of leather or suede, can be either split, providing more flexibility, or rigidity. Heels are usually 3.5 cm high, with the outer sole thickness also altering the tap shoe's tone and weight.

There are a variety of styles of shoe (see Figure. 38) with every shoe producing a different sound. The most common tap shoe is the *Oxford shoe* (which includes two-tone spectators or patent leather, suede leather variations, which is very common in jazz dance. Other varieties include, *Mary Jane* shoes (usually for beginners), character shoes, sneakers with taps and even tap dance pointe shoes (see Figure. 39), which facilitated the 'toe tap' style of dance. As Nemr describes,

> Toe Tap, as it was called, was classified in the same group as the stair dance, the chair dance, the cane dance, and tap dancing on roller skates. Each one of these kinds of routines added variety to the form of tap dancing. Whether what the new kind of routine added to the craft was considered novelty for novelty's sake, or truly innovative was left to the opinions of the audiences, critics, and ultimately history. What all of these novel interpretations of tap dance had in common was the use technology to augment the craft of tap dance (AndrewNemr.com 2016).

Fig 39. Tap pointe shoes[45].

Tap dancing makes frequent use of syncopation (emphasizing an unstressed beat) and improvisation. It can either be done with music following the beats provided, or without musical accompaniment; the latter is known as *a cappella* tap dancing. In tap, there is a wide variety of steps, and in advanced tap dancing, basic steps are often combined together to create new steps. Many steps also have single, double, and triple versions, including *pullbacks*,

[45] See tap dance "en pointe" for a 1950's example of toe tap en pointe, https://youtu.be/kORXvs8OfJI

timesteps, and *drawbacks* and various types of turns can be done, including the *step heel*, *Maxi Ford*, *cramproll* and *drag* turns.

Tap dancers over the years have created many individual styles with some dancers combining other forms of dance. Tapper Fred Astaire provided a more ballroom look to tap dancing, while Gene Kelley introduced ballet elements into tap. This style of tap led to what is today known as *Broadway style*, which is popular in American culture. It often involves high-heeled tap shoes and show music, and is usually the type of tap first taught to beginners. *Hoofers* are tap dancers who dance primarily 'closer to the floor', using mostly footwork and not showing very much arm or body movement (Valis Hill 2010). Slaves in America employed this kind of tap dancing, also called rhythm tap. Eccentric dancing, which includes acrobatics, snake hips, the shimmy, and any other form of contortionist movements or comedy dance, was first introduced in the style called 'legomania', or rubber legs (Frank 1994 as seen in Lewis 2013). Incorporating high kicks, legomania is best known in the 1939 film *The Wizard of Oz*, where the scarecrow, played by Ray Boger, made it famous in the performance of "If I Only Had a Brain" (Frank 1994, cited in Lewis 2013).

Figure 40. Fred Astaire performing *ceiling dance*, film still from *Royal Wedding*, 1951.

The literature on tap has introduced early African pioneers of the art form on slave ships when the dance was then known as *jigging*, or *vernacular dance*, or *Buck and Wing dancing*, or *step dancing* which informed contemporary Tap. Dance was a medium of cultural identity and expressed through their dance languages of shuffling, sliding, stomping and 'the shout' which in a way was an escape from their caged situations and offered momentary free expression and a liberation. Possibly, later day performers inspired by this cultural dance form, (one of many well-known examples) Fred Astaire kept this otherworldliness and escape from the everyday that tap dance embraces, as in figure 40. where Astaire is walking up the walls, which is also comparable to the earlier displays of the feminist, cross-dressing, fast and furious tap dancing of Black Vaudeville, Whitman Sisters who Constance Valis Hill and Margaret Morrison describe where "the audience would roar as the young dancers turned flips, ran up walls, and generally defied gravity" (Valis Hill 2010) just like Astaire performing the ceiling dance.

2.7 Shoes as technology

There is a rich history of shoe-based tools that enable the feet to perform specific tasks or affect the wearer. My current project, the *computer enhanced foot wear*, build onto the great legacy of work conducted in the field of technology enhanced foot-wearables to date and invented shoes to perform specific tasks.

2.7.1 Double Decker Shoes and Detachable Heels

A key example of shoes being physically modified to affect the movement and height of a performer are the shoes conceived by May West (see figure. 41). These 9.5-inch, "Double Decker" customized shoes feature a top-set platform designed to be hidden by a skirt hemline. They changed the meaning of the original high-heeled shoe and its functionalities, making her walk in a different way. Similarly by changing the original form of a high-heeled shoe, several methods of adding a detachable heel to a shoe have been patented.

The first patent for a detachable heel was by inventor Manual S. Gutierrez in 1930, then in 1948 by Mancuso Frank M, in 1956 André Perugia also invented (U.S. Patent # 2,795,866 | Filed July 31, 1956 - Granted June 18, 1957) the changeable heel was commercialised by I. Miller (see Fig 42.). Other changeable heel inventors include (but not limited to) Mary Elliott Kathleen in 1948, Zuckerman & Longobardi in 1957 and Luis D. Urbano in 1965. Each patent suggested different ways to attach interchangeable heels to shoes. The style never caught on but is always reintroduced every 10 years or so by another designer (Walford 2014).

Figure 41. Mae West's *Double Decker heels*, 1950's, image courtesy of FIDM archive, Los Angeles, 2016.

Figure 42. Left: Advertising campaign *Perugia invents ... I. Miller presents…The changeable heel,* 1956.
Right: *Perugia for I. Miller Heel*, a lock is inserted into the rail, 1956.

2.7.2 Singing and dancing shoes

Through the use of circuits, sensors and electronics, various shoes have been designed or enhanced to create sound. One of the first technology-enhanced examples include the *Sound producing dancing shoe* (1930) by J.H. Smith, U.S. Pat. No. 1,744,513, (see Figure. 43).

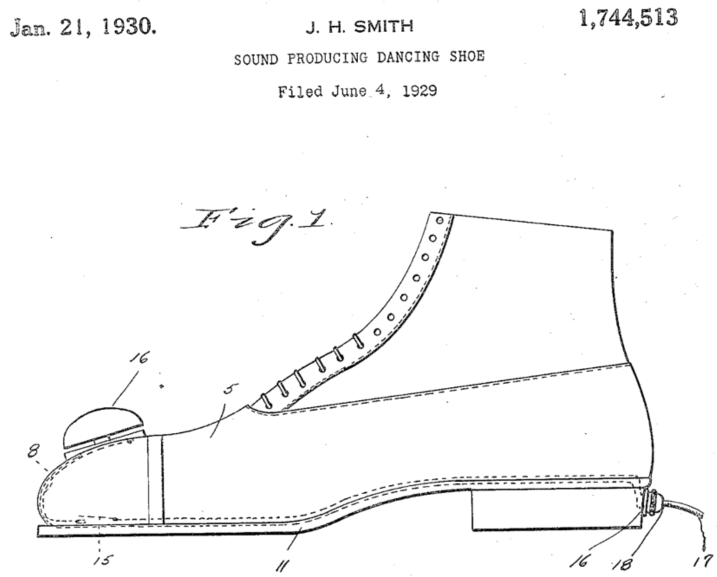

Figure 43. *Sound producing dancing shoe* US 1744513 A by J.H. Smith Patented, drawing published 21.01.1930 (Google Patents).

More recently, Alfred Desio first used his invention *Tap-Tronics* in concert in 1982[46] (di Perna 1988), where each dancer wore electronically amplified tap shoes. A transducer microphone was fitted into a tapper's shoes wired to a transmitter, which was either hand-held or placed in the pocket. The tap sounds were relayed to a receiver and routed via several different audio effects.

Other recent example is *Midi tap dance shoes* (2006) by Claude Francis Juhen. For this work, store bought shoes were retrofitted with stereo jacks on the back heel of the sole, with the stereo jack cable connecting the sensors of the shoes to two respective wireless modules. These modules sent sensor values to the receiver, which communicated MIDI to a custom Max patch controlling video and sound. Modifications to the shoe allowed it to become a modular instrument or controller.

[46] Taptronics demonstration https://www.youtube.com/watch?v=i0TeWo6Escg.

2.7.3 Magic shoes for winning at roulette

The world's first wearable computer on a belt attached to a shoe was made by Edward Thorp[47] in 1961[48], an engineering research project in collaboration with Prof. Claude Shannon, a fellow MIT student. The foot and its modified shoe, was a secret input device for data collection, analysis, and retrieval purposes for a system to beat Roulette. The invention comprised of twelve transistors, and a cigarette-pack sized computer, which was fed data by switches operated by the big toes. One switch initialized the computer and the other was for timing the rotation of the ball and rotor. The computer predictions were heard by the computer wearer as one of eight tones via an earpiece (Thorp 1998).

Thorp and Shannon having analysed the ball on the various wheels, predicted where the ball stopped based on the combined knowledge of its starting point and velocity. As the ball was launched, the in-shoe wearable device would be activated to begin calculating its velocity and eventual landing point. Once this algorithm was set in motion, the computer then radio-transmitted a musical scale to a hidden earpiece worn by another person in order to communicate the predicted landing slot of the roulette ball.

Valerie Lamontagne suggests the early invention of Thorpe can be compared to the logic of current consumer wearable technology gadgets today in that they are input devices, such as sports bands with biometric readings, of which reflects the "cybernetic impetus toward regulating systems and controlling outputs. Ultimately, such devices aim to streamline data—collected from the body or the environment, for instance—process it, and feed it back to the wearer via a Wearable Tech visualization interface with the aim of improving the user's everyday quality of life. The ultimate goal of these consumer devices echoes a self-imposed cybernetic mirror that could be seen as an opt-in form of self-control" (Lamontagne 2017, p. 33).

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[47] Edward O. Thorp is credited as creating the first wearable computer in 1961, "The Invention of the First Wearable Computer," *Proceedings IEEE International Symposium on Wearable Computers* (ISWC 1998) https://www.cs.virginia.edu/~evans/thorp.pdf. Thorp earned a PhD in mathematics from the University of California, Los Angeles, in 1958, and worked at MIT from 1959 to 1961. Thorp is also a pioneer in probability theory, best known for his bestseller book, *Beat the Dealer: A Winning Strategy for the Game of Twenty-One* (Vintage, 1966).

[48] "The first wearable computer was conceived in 1955 by the author to predict roulette, culminating in a joint effort at M.I.T. with Claude Shannon in 1960-61. The final operating version was rested in Shannon's basement home lab in June of 1961. The cigarette pack sized analogue device yielded an expected gain of +44% when betting on the most favoured "octant." The Shannon and Thorps tested the computer in Las Vegas in the summer of 1961. The predictions there were consistent with the laboratory expected gain of 44% but a minor hardware problem deferred sustained serious betting. They kept the method and the existence of the computer secret until 1966" (Thorp, 1998, pp.4).

In the late 70's a group of UCSC students were drawn together in a monumental effort to predict the unpredictable, calling themselves The Eudemon's[49], inspired by Thorp and Shannon's work, went on to iterate on their ideas of assisting a roulette player predict where the ball would land on the roulette wheel. The Eudemon's created a more compact Eudemonic computer in a shoe (see Figure. 44 and Figure. 45).

Figure 44. Shoe computer, the Eudaemon's roulette system, *The Eudaemonic Pie* display at the Heinz Nixdorf Museum.

Their goal was to achieve happiness (and a little financial security) for themselves and their friends via the roulette wheels of Las Vegas (Bass 1985). "In various implementations, two players would collaborate: one would watch the ball and click a footswitch each time it passed, while the other would receive this timing information wirelessly from the second person who was to place the bet. The shoe-based computer, by using a physical model of the roulette table, based on nonlinear dynamics, would indicate one of nine possibilities: a particular octant, or a ninth suggestion that no bet be placed. One of these nine possibilities was presented to the bottom of the foot in the form of vibrations of three solenoids which were each programmed to vibrate at one of three possible vibration rates (slow, medium, or fast). The person placing the bets would need to memorize the numerical values in each octant of the roulette table, as

[49] eu-dae-mo-nism n. [Gk eudaimonia happiness, fr. eudaimon having a good attendant spirit, happy, fr. eu- + daimon spirit](1827): a theory that defines moral obligation by reference to personal well-being through a life governed by reason (Webster's Ninth New Collegiate Dictionary).

well as learn the nine different vibration patterns that the three solenoids could produce" (Mann 1998).

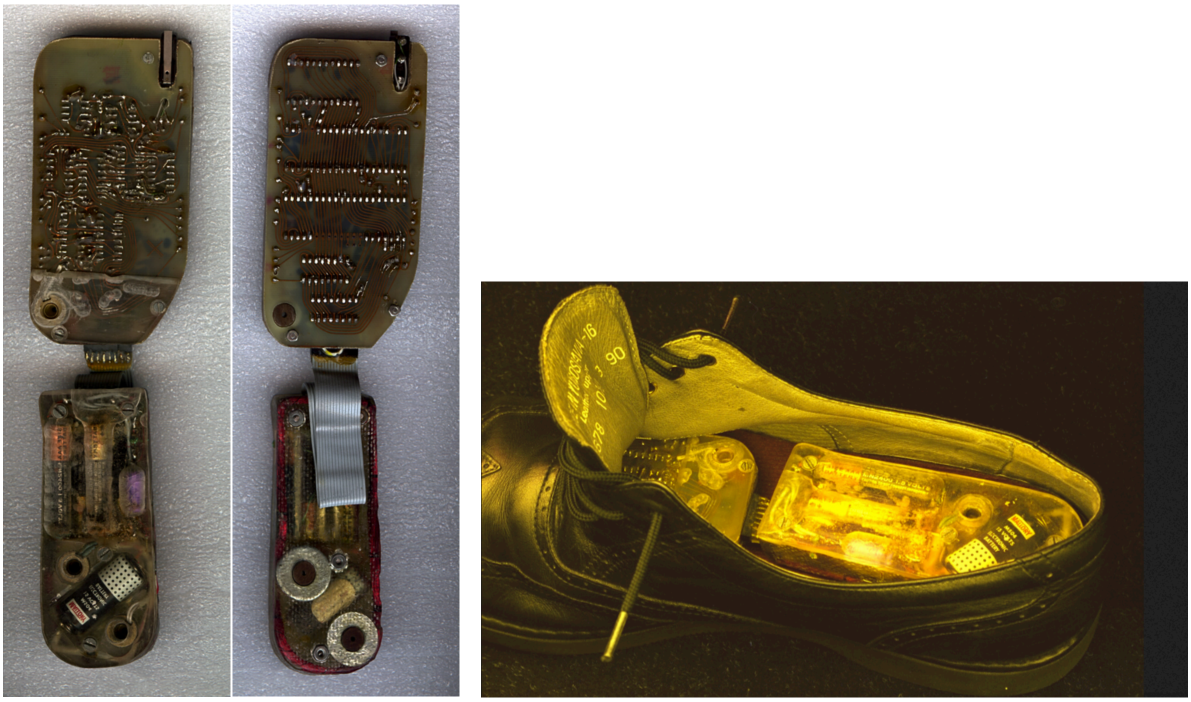

Figure 45. *Eudaemonic Shoe and Computer,* 1998.

Unfortunately, though the Eudaemons managed to amass about $10,000 before having to quit due to malfunctions in the machine – it had been administering electric shocks to its users and burnt one of them, leading them to abandon the group.

2.7.4 Democratic shoes for musical style

Uses of shoes as fashionable, acoustic accessories includes the work by Ricardo O'Nacimento from POPKALAB, with Phonotonic and Stephane Gontard who created a pair of multi-tech shoes called SoundSteps (see Figure. 46) that allow the wearer to create sounds and music through their own movements.

The movements include steps, jumps and turns, which were sensed by an accelerometer, FSR and gyroscope. With this product, they hoped to democratise the creation of music, enabling anyone to create sounds, which are broadcasted through an inbuilt speaker. The technology was hidden inside an added 'tongue' above the shoelaces on an already existing shoe, instead of being built into the shoe sole or designing a shoe specifically around the technology.

Figure 46. *SoundSteps* by Ricardo O'Nacimento (POPKALAB).

Another work by O'Nacimento is the *Recording Shoes* (see Figure. 47) is a collaboration project with fashion label BLESS, which uses their already existing iconic *Eram Knitt*, ankle boot. The boots record and play back noises using steps as a trigger. Ricardo's idea was to create a 'sonic confusion' with the wearer feeling as if they were walking while standing still.

Figure 47. *Recording Shoes* by Bless and Ricardo O'Nacimento (Popkalab).

O'Nacimento's shoes are not really musical instruments but rather acoustic accessories that produce sound effects to the movements of the wearer. They also are not focused on the expressivity of the foot using sound synthesis as I am and rely on pre-set MP3 music files or live recorded sounds, which are not in the same trajectory as my research. However, an appealing aspect of his shoes are that he always added the technology onto an existing design, rather than radically altering the visual aesthetic of the actual designs or designing a specific pair of shoes from the ground up.

Converse's *Chuck Taylor All Stars* have always had a connection with music. Groups like the Ramones in the 1970's and 1980's or Nirvana's Kurt Cobain in the 1990's made the shoe a part of their signature style. The *All Wah,* conceived by the design agency, Critical Mass in 2013 during a hackathon, is a high-top *Chuck Taylor* with a built-in Wah pedal, metaphorically speaking. Simply by moving the front of the foot up and down, the technology embedded in the shoe adds a Wah peddle like filter effect to any plugged-in guitar.

Fashion technology brand CuteCircuit took Critical Mass' original concept and developed it further, removing the cables and making it entirely wireless (see Figure. 48). A giro sensor in the sole of the shoe registers movements similar to those of pressing an actual Wah pedal. The motion data is sent via Bluetooth to a Wah Box, giving a guitar the desired effects. A press release that was sent out by the company, made no mention of when or if the *All Wah* will be available to the public, though thirteen guitarists did get their feet in them to test out live on stage in mid 2016. It seems the invention is more of a fashion-marketing ploy for the brand than an actual sound effects controller for the mass public.

Figure 48. The *ALL WAH* by Converse, 2016.

A final, similar model of sneaker/street shoe, as a custom 'concept' prototype controller (the shoes don't physically exist) are the *Mi Adidas Roland TR808* by Neely and Daughters. The shoes are a coupling of an Adidas shoe with the cult Roland TR 808 analogue drum machine, and are equipped with volume control and are able to play back six different pre-set drum beat patterns (see Figure. 49).

Figure 49. The *Mi Adidas Roland TR808*, 2017.

2.8 Shoe sensing and expressive footwear

Examples of bodysuits working with shoes as gestural controllers include the commercial *Brocton-X Drum Suit*, with body percussion sensors and heel-mounted triggers; and the Yamaha *Miburi* introduced in Japan in 1994, a system containing hand-held keypads, resistive band sensors in the shoulders, cuffs and elbows of the vest and piezoelectric pickups in the heel and toe of the shoes (Jorda 2005).

Figure 50. *Internet Connected Shoes* by Steve Mann, 1996.

In 1996 Steve Mann turned his own Nike running shoes into technology-enhanced footwear (see Figure. 50) by equipping the shoes with sensors to measure the impact of the shoe with the ground. He saw this as a way to enabling the wearer to "pace themselves with a distant partner, connected through wireless communications" and enhance their capabilities of self-expression (Mann 1997).

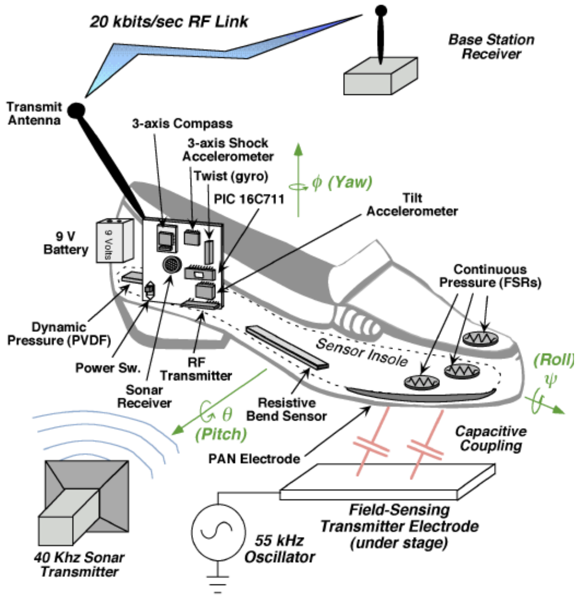

Figure 51. *Expressive Footwear* by Joseph A. Paradiso & Eric Hu, 1997.

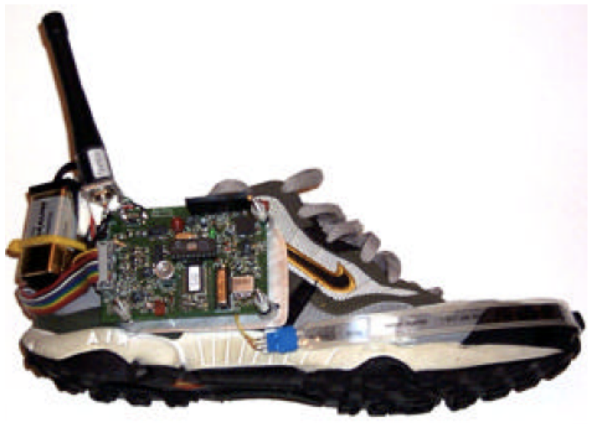

Figure 52. *Cyber Shoe* by Joe Paradiso and Eric Hu, 1999.

Joe Paradiso and Eric Hu made *Expressive Footwear* in 1997 (see Figure.51) using a commercially manufactured Capezio *Dansneaker* (Paradiso and Hu 1997) and later named the *Cyber Shoes* (see Figure.52) where circuits were mounted on the side of the *Nike Air Terra Kimbia* which were chosen as they matched the costumes they had chosen for choreographers (Paradiso et al. 1999). Paradiso's *Expressive Footwear* functioned more as music controllers to drive synthesizers during computer-augmented dance performances (Paradiso and Hu 1997) than being visually aesthetic, self-contained digital music instruments, the shoes having been bought and repurposed with the circuits placed on the side of the shoes, more as an afterthought than integrating the circuits in the design of a unique shoe specifically for the purpose of dance performance. The *Expressive Footwear* sensors enabled degrees of movement to be measured, this measurement of position, orientation was intended to enable expression and was mapped to various sounds in a detached computer. The sensors and their capabilities included: gyroscope, compass, a magnetic vector sensor based on permalloy bridge, which estimated the bearing of the dancers feet to the earth's magnetic field, dual axis accelerometer(measuring tilt, velocity and any jumping movements the foot makes), electric field sensing was used to monitor the lifting of the feet, bidirectional FSR (force sensitive resistors) strip to measure sole deflection and bending response, 2 piezo electric pads (constructed from laminated sheets of PVDF, polyvinylidene fluoride polymer) one inserted under the big toe and one under the small toe measuring 'differential pressure', and one pad under the heel measuring 'dynamic pressure' and 'vertical shoe displacement' (Paradiso & Hu 1997, p. 2).

Their motivation was to design a wireless shoe controller contained entirely on the foot, and with enough sensors to describe all possible foot gestures including: twists, jumps, kicks, weight distribution, distance of foot from floor (using electric field transmitters) and more. The sensor data controlled external synthesizers via C++ based libraries. Dancers performed with expressive footwear numerous times in the United States, Tokyo and Paris. However, while expressive footwear's hardware design was robust, reliable, and sophisticated, the mappings focused on demonstrating the technology with 'simple sound-action mappings'.

There have also been several applications of employing sensors in the manufacturing of shoes for medical applications and sports:

- pressure sensing insoles for paediatric foot-health (Cavanaugh et al. 1992)
- rehabilitative treatment and fall detection systems for elderly people (Simm et al. 2011)
- managing wandering behaviour of elderly people, such as the *GPSshoes*
- warming feet (www.digitsole.com)
- improving golfers' swing (www.probalance.com)
- heel strike energy and heel bending energy are harvested, used by consumers to charge mobile phones and other electronic devices on the go (Shenk and Paradiso 2001).
- tracking runners' metrics, such as Nike+ and Adidas MiCoach which both connect to running apps.

Recently there have also been developments in shoe interfaces for virtual reality, which used to just focus on the hands and head. Now many are extended to the feet using an array of sensors mounted in the insoles, with haptic feedback being applied driving vibrators in the sole and using GPS systems. For example, *ShoeSoleSense* (Matthies 2013) is a wearable foot interface for real and virtual environments, which enables location-independent, hands-free interaction through the feet.

These are due to the increasing proliferation of sensing, communication, and computing techniques, becoming more available and financially viable in recent years (Spinsante 2017).

2.9 Conclusion

In this Chapter I presented my own artistic practice into developing objectinstruments to use in the gesamtkunstwerk contexts of Chicks on Speed a group I collaborate on with Melissa Logan. Following on I described the rich body of literature from a range of disciplines, including; anthropology, medicine, performance art, shoes as costume statement and invention or prosthetic followed by the semantics of props and new musical instrument design. The aim of this chapter was to identify the various fields and writings that have motivated my artistic practice and research enquiry over the last five years (building on my past experiences in Chicks on Speed), relating to philosophical and cultural understandings of shoes in society and feet in performance.

Chapter 3: Methodology

3.1 Introduction

This research project addresses the following research questions:

Question 1

How can digital technology embedded in high-heeled shoes and foot apparatus change what we can do with feet?

Question 2

What are the design techniques for computer enhanced foot apparatus/high-heeled shoe-based digital musical instruments that facilitate unusual audiovisual theatricality, expression and experimentation?

Question 3

What cross disciplinary approaches can be used to develop *computer enhanced footwear*?

Question 4

What are the artistic opportunities of *computer enhanced footwear* and using our feet in different ways?

The focus of this research project has been to attempt to answer these questions through artistic practice using qualitative social science research methodology of an *exploratory research* nature. The main concern of this project is to advance our understanding of the potential of foot/shoe-based wearable technologies for creative theatrical performance. The research questions addressed, and artistic practice conducted are mechanisms that helped to develop this new knowledge and this understanding.

This research seeks to establish imaginative *modus operandi*, pushing the boundaries of artistic practice and critical analysis, which requires some consideration of the ontological and epistemological positions which underpin the research methods that have been applied.

With this thesis, the aim is to create a new mode of interacting with technology to change what we can do with our feet, to quote Scrivener:

> Technology and design share a common concern for generating artefacts that are intended to transform the world from what it is to something better: both are concerned with intervention, innovation and change (Scrivener 2000, p. 1).

In keeping with Scrivener's stated role of 'design research', to 'effect change', this exploratory research is specifically concerned with *kinaesthetic consciousness* and *phenomenological* states of mind affecting physical, acoustic and aesthetic change. It is an engagement of deep exploration facilitated through technology, iterative making processes and performance art with computer enhanced foot apparatus. The chosen methodology and methods to answer the research questions will be explained in the next section in detail. These include *action research*, *reflection-in-action, reflection-on-action* and *practice-based research*.

3.2 Theoretical Model

3.2.1 Terms and Concepts

Before detailing the qualitative research techniques used in this study, it is necessary to place them in context of why these particular techniques are used and the underlying philosophical basis for methodological decisions. Different research communities have different ways of investigating and validating research. Research into foot/shoe-based musical instruments and their uses in audiovisual theatrical performance draws on literature, theory and practice from a variety of disciplines (making it cross disciplinary in nature). That is, while its members might identify as a community, they are not necessarily bound together by a particular phenomenon of interest and accepted methods.

Before further discussion of knowledge generation, it is necessary to consider some perspectives on what knowledge is with consideration of the ontological and epistemological positions which underpin the research methods that have been applied. Crotty (1998) identifies foundational elements of research including epistemology, theoretical perspective, methodology and methods. Each subsumes and informs the next. In this chapter I will examine each general qualitative research methodology and how it is applied as an exploratory method in the context of the research.

A research paradigm carries with it fundamental assumptions about reality (ontology) and what and how we know about that reality (epistemology). Ontology and epistemology are terms used variously in different fields. Here I will only deal with them in the context of research paradigms and how they affect the character of this research.

Ontology is concerned with such questions as what is real or not? What is fundamental and what is derivative? What is a property of what? Epistemology is concerned with the nature of knowledge. What is it to know? On what does this knowledge depend and how can we be sure of what we know or claim to know? Taking lead from Crotty (1998), I will generally subsume ontology into my discussion of epistemology since the two tend to emerge together. The epistemological position taken in this research is *constructivism*, that is, knowledge is developed and transmitted in a social context. As Crotty (1998, p. 42) writes:

> All knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social context.

The *constructivist* epistemological position is at the heart of an *interpretivist* theoretical perspective in looking for culturally derived and historically situated interpretations of the world. The focus, like much qualitative inquiry, is on generating (rather than validating) theory. The epistemological position and theoretical perspective thus informs the research approach, in terms of the methodology and methods used to answer the research questions.

Exploratory research

Exploratory research is research conducted for a problem that has not been clearly defined. It often occurs before we know enough to make conceptual distinctions or posit an explanatory relationship. It should draw definitive conclusions only with extreme caution. Given its fundamental nature, exploratory research regularly concludes that a perceived problem does not actually exist (Scrivener 2000). Exploratory research often relies on secondary research (such as reviewing available literature and/or data), or qualitative approaches such as informal discussions with artistic performers and the public, peers and expert stakeholders. It can also use more formal approaches such as in-depth interviews, focus groups, projective methods and case studies.

When the purpose of research is to gain familiarity with a phenomenon or acquire new insight into it in order to formulate a more precise problem or develop hypothesis, ‘exploratory studies’ (also known as formulated research) are useful. If the theory happens to be too general or too specific, a hypothesis cannot be formulated. Therefore, exploratory research is used to gain experience that is helpful in formulating relevant hypothesis for more definite investigation (Earl 2007). The results of exploratory research are not generally useful for decision-making by themselves, but they can provide significant insight into a given situation. Although the results of qualitative research can give some indication as to the why, how and when something occurs, it cannot tell us how often or how many.

Social exploratory research seeks to find out how people get along in the setting under question, what meanings they give to their actions, and what issues concern them. The goal is to learn 'what is going on here?' and to investigate social phenomena without explicit expectations (Schutt 2011). Qualitative research or interpretive research is an attempt to unearth a theory from the data itself rather than from a predisposed hypothesis.

Phenomenology

Embodied knowledge, explored in phenomenology, has been practiced in various guises for centuries before it had this name. It has been argued that when “Hindu and Buddhist philosophers reflected on states of consciousness achieved in a variety of meditative states, they were practicing phenomenology” (The Stanford Encyclopaedia of Philosophy 2016).

Phenomenology was popularised in the early 20th century, beginning with Edmond Husserl, the founder of phenomenology and continuing via Heidegger, Sartre, Merleau-Ponty and others. Phenomenology acknowledges the value of the experiences from the first-person point of view versus disembodied mind-based thought and knowledge. Husserl’s phenomenological investigations eventually lead to the notion of kinaesthetic consciousness, which is not a consciousness ‘of’ movement, but a consciousness or subjectivity that is itself characterised in terms of motility, that is, the very ability to move freely and responsively’ (Behnke 2004).

This is relevant to this research as it is not concerned with ‘looking at’ performing with the *computer enhanced footwear* from the perspective of the audience, but with the personal experiences of 'performing with' the shoes and temporary foot apparatus. This sometimes took place in fabrication spaces whilst making and performing with the appendages or in collaboration with other performers on stage, with the body as the centre of orientation. Husserl (1913/1962) terms this 'eidetic phenomenology'.

Martin Heidegger proposed that objects may be experienced in two different ways as 'ready to hand' and 'present at hand' (Heidegger 1962). When an object is 'ready to hand' it performs like a seamless extension of our bodily motions. When an object is 'present at hand' we perceive it as independent of our bodies, as an agent to be acted upon and with, rather than through (Wilde 2015). My computer enhanced foot devices cannot be physically separated from the foot, the two are tightly and consistently coupled to carry out theatrical tasks.

Merleau-Ponty (1945/1969) referred to knowledge as being "in the hands" (p. 147). He described how in 'bodily knowledge' or 'embodied knowledge', the body assumes the place relating to intellectual knowledge, making the pre-reflective bodily closeness with the world around us into the foundation of our thinking and acting (ibid). The theme of embodied knowledge (first person point of view) relates to situations where the entire body is the location of knowledge.

Taking this into account, in relation to performing with other artists on stage, I firstly introduce the Heideggerian (1962) terminology 'mitsein' (being-with). The term 'mitsein' refers to an ontological characteristic of the human being, that it is always already[51] with others of its kind. This is a statement about the being of every human, that in the structures of its being-in-the-world one finds an implicit reference to other humans. In relation to this research, it is an essential element of the *computer enhanced footwear* and use of technology because it is carried out from a social perspective—it takes into account the theory of 'humanistic intelligence'[52] (Mann 2001)—rather than an 'artificial intelligence'.

Garnet Hertz (1995) suggests "artists can provide a conscience or humanizing element to the technology" (Candy & Edmonds 2002). I believe this is important for my practice and my research objectives. This is because the artistic decisions made during the research were not made in isolation but with others. Collective human decisions and responses to situations guided how the technology was used.

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[52] See Appendix E: Definition of Terms.

Similarly, when Nietzsche speaks about his idea of a 'free-spirit', he explores multiple ways of interpreting human behaviour and norms:

> We must take care not to establish our life on too narrow an area of desires: for if we renounce the joys that position, honours, companionship, sensual pleasures, comforts, the arts afford, the day may come when we discover that through doing without these things we have acquired for a neighbour, not wisdom, but boredom with life (Nietzsche 1886/1996, p. 290).

Drawing a parallel between Nietzsche's concept of the 'free-spirit' and action research (which is social and collective), I attempt to approach my artistic practice-based research process in a free-spirited manner. I do so with an understanding that I do not act in isolation and require a context in which to create, react, dialogue and perform my theoretical position. In addition, the performance of the footwear I create requires other participating performers. Their personal phenomenologically informs 'embodied' feedback and leads to a chain of reactions on stage and off stage. Through series of collective improvisations, participants in my research react off each other to impact and shape the design processes and theatrical uses of the foot prototypes.

3.3 Research Design

The overall research design is informed by the following research methods:

- **Action research**; Kurt Lewin's (1944) reflective process of progressive problem solving led by individuals working with others in a social context or as part of a team to improve the way they address issues and solve problems.
- **Reflection-in-action** and **reflection-on-action** research methodologies by Donald Schön (1983), which are based on the character and development of professional knowledge.
- **Practice-based research** are creative production projects in technology, art and design informed by Ernest Edmonds, Linda Candy and Andrew Johnston (2008).

3.3.1 Action research

Initially coined by Kurt Lewin (1946), *action research* was also adapted by Chris Argyris (Argyris et al. 1985) and others in the early 1980s under the name of *action science*. The methodological approach consists of an iterative cycle of planning, action, discussion in participation with others (together with observation) and reflection. Kemmis and McTaggart (1988, p. 10) describe the process:

1. to develop a plan of critically informed action to improve what is happening
2. to act to implement the plan
3. to observe the effects of the critically-informed action in the context in which it occurs
4. to reflect on these effects as the basis of further planning, subsequent critically informed action

   …and so on through a succession of cycles.

The *Action Research Spiral* (see Figure 53.) relates to a succession of cycles and the opportunity of reflecting and analysing a phenomenon in a greater depth at each stage of the project (which may overlap). Consequently, the cyclic process results in a greater level of understanding about the problem.

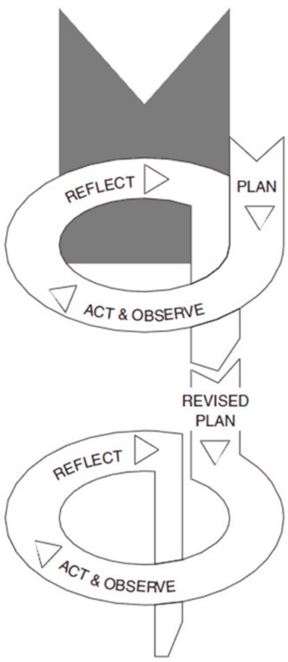

Figure 53. *Action Research Spiral* (Kemmis and McTaggart 2000).

Certainly, planning, observing and reflecting are steps any good research practitioner should be doing, but the distinction that action research calls for is that it requires extensive rigour and theory building. This form of research emphasises participatory approaches, where the researchers are often also the subjects of the research (as is the case with this dissertation). Another important characteristic of action research is that the goals and methods naturally vary along with changes in the researcher's understanding via the multiple cycles of reflexive practice.

Action research is also typically used in collective activities and tends to privilege 'getting something done' over theory building. It also aims at solving a specific problem—whereas my own investigation aims to explore a problem space—the problems *and* the opportunities they present.

3.3.2 Reflection-in-action and Reflection-on-action

Reflection-in-action

Donald Schön's research methodology reflection-in-action (Schön 1983/1991) presents a theory of practice that provides expert practitioners with a method for observing and reflecting on their practice, while engaging in a process of continuous learning and improvement on their knowledge of practice. Reflecting in action is what experts do when they deal with a situation, reflect on a past situation and go about solving a present problem based on their practical professional experience. As Schön (1983) describes:

> When a practitioner sees a new situation as some element of his/her repertoire, he/she gets a new way of seeing it and a new possibility for action in it, but the adequacy and utility of his/her new view must still be discovered in action. Reflection-in-Action necessarily involves experiment (p. 141).

Reflection-in-action is the spontaneous, performance of every day actions which show us to be knowledgeable in a special way—sometimes with us not knowing what we know (ibid.). Schön proposes that our knowing is a kind of tacit knowledge that we gain through acting out patterns of action and how we feel whilst enacting out our practice— a 'knowing-in-action' whereby a practitioner can identify phenomena.

‘On-the-Spot experimentation’ (Schön 1983) facilitates new understandings during an ongoing process of enquiry, providing new discoveries and unexpected outcomes. It also facilitates a reframing of research outcomes at milestone intervals during a timeline of creation and enables observation from multiple perspectives. On-the-spot experimentation in this thesis is based on understandings from Schön’s position. Its application has informed a series of spontaneous consequences, implications and reinventions which have, in turn, supported the formation of new theories.

Schön (1983) also describes a design situation as something that lacks clarity until it is set in motion. This is applicable to the ongoing process of discovering ways to invent and build my foot apparatus physical prototypes. I found that solutions were not clear until I was having a “reflective conversation with the situation” (Schön 1983, p. 76). For example, during my prototyping of *CEF*, making mistakes or doing things another way with CAD (computer aided software design) or CAM (computer aided machining) processes led to new findings, unexpected opportunities and new artistic outcomes. I then made decisions based on those findings as part of the iterative design process chain, which bled back and forth between prototyping and performance (which is also entangled in Reflection-on-action which I will unpack next). I organically found greater clarity as the process was set into motion. As Schön describes, “stimulated by surprise, they turn thought back on action and on the knowing which is implicit in action” (Schön 1983, p. 50). In support of Schön’s idea of practice changing through the process of making, Johnston suggests:

> Design draws on creative practice, supports creative practice and, importantly, changes creative practice. Creative practice is not always an existing, fixed constraint within which we must confine ourselves. By creating NIMEs (New Interfaces for Musical Expression) we change practice (Johnston 2014).

Reflection-on-action

Reflection-on-action involves reflecting on how practice can be developed, changed or made better (iterated). After the step of making something “We reflect on action, thinking back on what we have done in order to discover how our knowing-in-action may have contributed to an unexpected outcome” (Schön 1983, p. 26).

In the context of this research, I have reflected on the unexpected outcomes encountered during the action of fabricating prototypes and performing them on stage. I undertook this reflective practice in a formal fashion, by writing down my reflections in a diary to capture new knowledge (build theory) (Scrivener 2000) and further develop my process of creating foot/shoe artefacts.

3.3.3 Practice-based research

According to Candy and Edmonds (2018, p. 63), "practice-based research is an original investigation undertaken in order to gain new knowledge partly by means of practice and the outcomes of that practice". It is this original investigation to produce new knowledge through creative practice and the resulting artefacts and processes of creation that is central to this dissertation (as well as my on-going professional artistic practice of 30 years). As Candy and Edmonds describe:

> [An] artefact 'might be an object, such as a table, painting or building. It might exist over time, such as a piece of music or a film. On the other hand, it might be less persistent in time, such as an exhibition or performance (2010, p. 123).

The term artefact describes an artistic outcome or object made by the artistic practitioner during a period of research, the outcomes of which may take the form of installations, exhibitions, objects or performances (Bluff 2017). In the context of this dissertation, the creative artefacts include:

- a series of analogue and computer enhanced shoe and foot-based apparatus
- live performances
- performance lectures
- music videos
- lens-based works.

Steven Scrivener argues that arts-based research and its resulting 'new knowledge' needs to be verified with its own set of standards, that an educated community needs to give feedback on (Scrivner 2009a). This idea is also supported by Borgdorff (2011), who writes:

> Because the artistic research addresses itself both to the academic forum and to the forum of the arts, the research documentation, as well as the presentation and dissemination of the findings, needs to conform to the prevailing standards in both forums (p. 58).

In the context of this research, it is necessary that stakeholders are knowledgeable in live art, new interfaces for musical expression, fashionable costume and/or footwear, in order to benefit from and respond to the research.

The idea that processes of designing and making artefacts can lead to theory has also been introduced by Caroll and Kellog (1989) whom claim computer enhanced artefacts can be an expression of psychological claims[53] and that these artefacts can be an outcome in itself. This claim is useful, however their criteria of evaluating such theoretical contributions (design science) embodied in artefacts is too limiting for this research as it is not necessarily functional and practical in terms of being designed for 'humanity at work' (Haynes & Carroll 2008). On the contrary, this research contributes a series of novel theories from the human and social sciences which cannot always be assessed according to the same set of criteria. There are artistic expressive qualities that are often unspoken (such as tacit[54], embodied knowledge or phenomenological practices). These qualities require other forms of evaluation, which cannot be accounted for by scientific philosophy alone (Dunne & Raby 1999, 2000; Markussen 2015).

Borgdorff (2011) examines artistic research as a form of knowledge production that invites 'unfinished thinking' where formal knowledge is not the outcome but the processes of 'thinking in, with and through art' is the subject. This implies that the process of iterative design and testing on stage in the making of physical artefacts is important in getting better understandings and outcomes when making shoe and foot apparatus for audiovisual expression. I would also add, that like phenomenological practices such as yogic philosophy, there is not necessarily an end to the process—it is ongoing.

[53] This is the know-how for bringing an artefact into the world and the artefact or interface's inner relationship (it's parts) and outer relationship with the world. In other words, an artefacts inner organisation and the way it relates to the outer environment (Simon 1996).

[54] Michael Polanyi (1966) describes tacit knowledge as being opposed to explicit or codified knowledge and is the kind of knowledge that is difficult to transfer to another person by means of writing it down or verbalising it. Interestingly, Nietzsche argued that the nature of language and words couldn't capture knowledge alone, but are rather metaphors. He also introduced the concept of 'sound-pictures' in his book 'Human all too Human: A book for Free Spirits' (1878/1996) which describes the way we perceive something, first through a nerve stimulus to mental image to mental sound and at this point we apply a specific descriptive analogy. Jonathan R. Cohen interprets Nietzsche's concept suggesting that words are made of something different, which can't correspond to reality.

Candy (2006) suggests practice drives the development of theory. She indicates, new knowledge can be generated through embodied practice and practice-based tangible outcomes (artefacts), and this knowledge is rigorously investigated in a research process leading to new understandings (knowledge) that are transferable. While the knowledge may be expressed in more than one way, the new understandings must be transferable in some way.

Michael Biggs and Daniela Buchler (2008) claim that research should be "disseminated, original and contextualised", arguing that the artwork or artefact alone without text cannot be seen as a research outcome. Candy, conversely, argues that in practice-based research, the text alone, without the artwork/artefact, cannot convey the full significance of the research:

> In *practice-based* research, any claims of originality and contribution to knowledge may be demonstrated through artefacts created during the research process such as artworks, musical compositions, performances and interactive new media installations. A full understanding of the significance of the research can only be obtained with direct reference to the artefacts in whatever form they may take (Candy 2011, p. 36).

Bruce Archer suggests "there are circumstances where the best or only way to shed light on a proposition, a principle, a material, a process or a function is to attempt to construct something, or to enact something, calculated to explore, embody or test it" (Archer 1995, p. 11). Archer goes on to define practice-based research as a systematic process resulting in new knowledge or a new understanding which is communicable.

The trajectory of practice-based research is non-linear and, I propose, messy at times. Conceiving of research as a step-by-step set of activities which move towards an intended goal assumes that "research is a cumulative process" (Biggs & Buchler 2008, p. 5). I believe intuitive, messy and aesthetic ambiguity are integral to researching creative practice in association with theatrical performance. (Especially in the case of my research which aims to communicate something strange and original). Such artistic-driven, practice-based research is also informed by the fluid relationships that exist between the performer, researcher and the researched, which are often collaborations that are improvised, organic and responsive in nature.

Practice itself is central to the research process in practice-based research. According to Borgdorff (2011), art practices, actions and interactions are made up of interwoven knowledge, experiences and understandings. "Methodologically speaking, the creative process forms the pathway (or part of it) through which new insights, understandings and products come into being" (Borgdorff 2011, p. 46). Thus, as Borgdorff (2012) suggests, research in the arts is an intentional act to articulate some of this embodied knowledge interwoven throughout the creative process and in the art object. This idea is supported by Johnston (1987) who suggests that abstract understanding emerges from bodily experience, and that there is a physical basis to imaginative structures of understanding.

3.4 Attributes of research methodology as method

In the context of my research, features and characteristics of the various methodologies and methods outlined above have guided my practice and theory-building in the following ways.

- Action Research; action-oriented approaches to the inquiry:
    - personal process of enquiry:
        - experiential
        - prototyping through iterative design processes
        - researching
        - performing in theatrical performances
    - collaborating through collective activities:
        - partnering and performing with Melissa Logan for our group Chicks on Speed
        - working with technologist and musician Dr. Sam Ferguson and forming an artist/technologist partnership to realise the outcomes of the prototype systems
        - developing artistic practices with other musicians, choreographers and makers on and off stage, in the fabrication laboratory, rehearsal spaces and performances on stage
        - undertaking artist-in-residencies to work with expert practitioners in various fields
    - identifying successful and unsuccessful fabrication and performance strategies through practice
    - contributing to both theory and practice in performance art and NIME
    - using an iterative approach of action and reflection in foot/shoe artefact prototyping and performance.

- Reflection in action:
    - identifying characteristics and refining prototypes based on fabrication and performance experiences in action
    - on-the-spot experimentation:
        - working with physical prototyping such as 3D-printing in the fabrication laboratory and reacting in spontaneous ways
        - having a 'reflective conversation with the situation' to find solutions
        - adopting new processes shown to me and reacting to situations that came up whilst:
            - prototyping during ArtScience residencies
            - performing on stage

- Reflection-on-action:
    - analysing documented performances with prototypes, e.g. observing and reflecting on spontaneous playing gestures of the feet and how they were incorporated into future performances (either in the same way or changed and improved) in lens-based works and videos
    - compiling a detailed diary of my own reflections and observations of:
        - iterating the system with Sam and other collaborating technologists[56]
        - conversations with collaborators[57]
        - exchanges with global artists, costume designers, fashion designers, curators, performers, wearable technologists, musicians and NIME experts throughout the research trajectory
        - experiences of stage performing with the prototypes
        - media about the performances – what other people were saying
    - conducting and documenting:
        - semi structured interviews with audience members and collaborators[58]

[56] See Appendix F: Project Acknowledgements.
[57] See Appendix F: Project Acknowledgements.
[58] I conducted these interviews early on and concluded that it was more valuable to mainly focus on my own reflections and observations. Although choreographers Krõõt Juurak and Marla Bendini's feedback after performances played a major role in the development of the physical shape of the prototypes and their choreographed playing gestures.

    - semi structured interviews with experts from the NIME field
  - meeting with research peers to reflect on research:
    - participating in weekly meetings with peer artists-in-residence, at Pier 9 Technology Centre, Autodesk, San Francisco
    - regularly meeting with CCC research group (Critical Curatorial Cybermedia Studies) and HEAD-Geneva University of Art and Design to discuss my artistic practice-based research over a two-year period.

- Practice-based research; developing artistic artefacts and design techniques through:
  - building upon 22 years of personal, professional artistic practice, including work produced as a member of Chicks on Speed
  - generating new understandings from the practices of making and performing with the artefacts and developing theory
    - researching literature from other sounding footwear inventors and artists using footwear in their performances, along with philosophical concepts of the feet and footwear in anthropology, their meanings over time in society and popular culture
    - designing and fabricating prototypes through iterative and experimental artistic processes
    - undertaking public performances, key-note presentations, panel discussions at art events and academic conferences to develop research
    - generating records of artistic practice such as this thesis and collateral publications[59] (including lens-based works and videos)
  - appraising practice outcomes to form a framework and new theory on the creation of *computer enhanced footwear* for audiovisual theatrical performance

- Exploratory research:
  - building upon Scrivener's (2001) suggested basic structure for a creative production project report (see Table 1.).

[59] See Appendix B: Publications.

Table 1. Technological artefact production research trajectory.

Rigorous reviewing of literature inform ideation and socio-political concerns of technological artefact
Technological artefacts and their material compositions are designed and fabricated based on reflection-in-action
Technological artefacts and their material compositions are tested and iterated on based on reflection-on-action
Technological artefacts are original in cultural context
Technological artefacts are a response to issues, concerns, learnt philosophical, technological and anthropological understandings and interests
Technological artefacts manifest these issues, concerns and interests
The issues, concerns and interests reflect cultural preoccupations
Technological artefacts contribute to human experience and improving other past artefacts
Technological artefacts offer new kinds of tacit knowledge when using them and generate new knowledge through theory building

3.5 Identifying Design Techniques

Once prototypes have been developed, it is necessary to identify their characteristics and their effect on the activities of the performers working with them during performance. From this it is necessary to identify the criteria that guided the technique. Not all such techniques are consciously decided upon at the beginning of the design process. Instead, they co-evolve with the design itself—the emerging design prompts the designer to change direction and revise the initial intentions.

Portillo and Dohr (1994) stress the importance of technique in order to both integrate process and solution and bridge the developmental junctures that lead to innovation. They define a design criterion as “a measure of value used by the designer to conceptualize, test and evaluate the project purpose in the design process” (Portillo & Dohr 1994, p. 409).

3.5.1 Key design technique questions

1) How should design techniques which guided the development of the *computer enhanced footwear* and devices be identified?

2) How should the experiences of performers using the foot and shoe based instruments be studied and used to inform the iterative design process of the artefacts?

3) How should the data gathered from the studies be analysed in order to build an understanding of what is going on and the relationship between the design techniques and the performers’ experiences and physical artefacts?

Design techniques used by the designer and the performer(s) in this study emerged from looking at the following:

- reflective diaries
- informal conversations and semi-structured interviews with performers and experts.
- comparisons of different versions of the prototypes as they develop.

3.5.2 Multiple case studies

To see how well the computer enhanced shoe and foot apparatus prototypes meet their design criteria, I studied the experiences of working with collaborating technologists during the development of the systems, my own experiences and those of performers interacting with the prototypes in experimental workshops and live art performances.

In regard to the system driving the audiovisual element of the footwear prototypes, I highlight here again the importance of collaboration with technologists[60], as I am not a software

[60] See Appendix F: Project Acknowledgements.

engineer. Throughout the project, I mainly worked in close collaboration with technologist and musician Dr. Sam Ferguson whose specialty was in turning my sound ideas into reality and communicating to me what was possible with the technology at hand. Together we formed an artist/technologist partnership to realise the outcomes of the systems of the main prototypes presented in this thesis. Billy Cluver sums up the fruits of art and technology collaborations:

> "The idea was that a one to one collaboration could produce something that neither of the two could individually foresee. And that was the basis for the whole thing, and the system developed from there" (Candy & Edmonds 2002, pp. 8).

Though the sound element is a large part of this research project, the creative culmination of ideation, iterative design, fabrication processes, performances of the shoes and foot apparatus and other artistic opportunities were all a part of the process. I stress that each of these elements are just as important as each other in the sum of the whole (to create a 'stage ready' audiovisual instrument prototype). I believe one needs to consider all these aspects of instrument design as interconnected and operating within a larger gesamtkunstwerk paradigm.

Given the philosophical and methodological (modes of practice) positions articulated earlier, and the core activity is an artistic one where it is expected that the results of the activity be unusual and surprising, I have chosen a qualitative approach. Although it would be possible to assign tasks to the other performers that would produce a measurable result, and such results could yield useful ways to make quantitative comparisons between the shoe systems (designed for specific individuals), the general validity attainable through such an approach would be at the expense of specific relevance to the substantive field of inquiry.

The choice and volume of performing participants was influenced by the issues discussed above. The sample size of performing participants depended on the number of pairs of shoes I had to test, where I was travelling to create the prototypes and the interest of local experts to participate. Expert dancers and performers participated in case studies along with curators, writers, critics and new musical instrument designers carrying out semi-structured interviews and open conversations. By 'expert' in this case, I mean performers who are sufficiently experienced in their art to be able to reflect upon and discuss what they are doing in a highly conscious way.

In discussing ethnographic approaches for foot/shoe system design, Crabtree (2003) suggests that the researcher also be reasonably expert in the domain under investigation so that he or she is more able to recognise significant events when they happen and to properly understand what is meant by the participants and when analysing the recorded protocols. As I am a researcher, 3D designer and maker (familiar with 3D software and 3D fabrication processes), practising performance artist and musician, experienced with contemporary practice and theory in instrumental as well as electronic music, this approach appeared to be appropriate.

Working alone as an individual, it is normal to have personal artistic insights. However, when working in larger groups one has other unexpected ideas and does things one cannot usually do alone. A group of people from different backgrounds (but who value each other's diverse approaches and contributions) can create more representations of philosophical and artistic concepts—leading to unexpected multifaceted and strange pathways. Collaboration therefore has an important role in the development of this research and the knowledge creation outcomes. This applies not only the performative collaborations on stage, but also the informal discussions and interviews throughout the progress of the PhD.

3.5.3 Structure of the Project

To further highlight the structure of my practice-based research project, and to compare it to other practice-based research, I have included below an overview of the entire structure of the project. This is based on practice-based research processes and outcomes outlined in Johnston's (2009) PhD thesis and modified by Ilsar (2017). The translation of these processes and outcomes for my project are as follows:

1. From **examination of the literature** state of the art in cross disciplinary fields:
    a. anthropology and natural history around feet
    b. shoe based musical instruments
    c. shoe based inventions
    d. artistic shoe costumes
    e. shoes in performance art
    f. cultural understandings of shoes in history, storytelling, fashion theory and pop music
    g. artistic foot prosthetics

combine with experience of past groundwork.

2. Identify initial **provisional design techniques** for foot/shoe-based prototypes developed from formal design criteria from this literature.

3. **Iterative prototyping process** – system and design and fabrication of physical prototypes.

4. Conduct a series of **performance case studies** as user studies to examine how I, and my collaborating performers, interact with *computer enhanced footwear* prototypes to further test them out.

5. Develop **applied design techniques**:

   a. system
   b. sound mappings
   c. physical prototype
   d. playing gestures

6. Derive a set of **design techniques** for foot/shoe-based prototypes of this type from research via steps 2 and 5 and from practice derived from step 4.

7. **Framework/refine design techniques** – The final refined design techniques for building this audiovisual foot apparatus as instrument is written up in this thesis

8. **Theory**–A new contribution of knowledge to the cross disciplinary fields of performance art, costume and musical instrument design (gesamtkunstwerk) outlined throughout this thesis.

Please note: I am working within the above structure, but not necessarily in this chronological order, as prototyping, performing with prototypes and further prototype, system and mapping design iterations can be done in several stages, not necessarily always in the same order.

3.6 Conclusion

In this chapter I have outlined my methodology to answer the research questions. In summary, I have pursued my practice using qualitative social science research of an exploratory nature, which deeply explores kinaesthetic consciousness and phenomenological states of mind. I have applied action research, reflection-in-action, reflection-on-action and practice-based research methods as well as case studies to develop my research about foot/shoe-based musical instruments and their uses in audiovisual theatrical performance.

At the end of this particular trajectory of artistic research, my output and contribution to knowledge in the field of new musical instrument design comes in the form of:

- artistic methods
- documenting the philosophical ideation formed by remixing of the literature
- strange iterative design and fabrication process of the physical artefacts to provide new artistic opportunities of the feet
- a new audiovisual instrument as costume for the feet
- artistic works such as live performances, films, exhibitions, performative lectures at conferences and lens-based works.

Having outlined my methodology, I will now present some of my key projects in the following case studies.

Chapter 4: Case Studies

4.1 Introduction

This chapter describes the foot-based instruments developed as part of this project in detail. In chapter 2, several techniques for building foot based musical instruments and artistic inventions were identified, along with understandings that feet—and the shoes which adorn them—have been the subject of various philosophical writings, technical design and artworks. This is because feet provide a stable base for our bodies, they can hold great symbolism and they can also facilitate artistic expression.

In chapter 3, an approach to research in this artistic domain drawing on practice-based research and action research, was described. In this chapter, I present the foot-based instruments that I designed and developed using my personal artistic method. The descriptions of the foot-based instruments in this chapter focus on conceptual design. However, I also briefly describe the 'technical systems' of each foot-based instrument prototype in order to illustrate how the aesthetic characteristics relate to technical systems.

So that readers of this thesis are more readily able to understand the interconnections between the iterative stages of prototyping, performing contexts and artistic opportunities of the foot-based instruments, Vimeo links to videos and lens-based works are provided.

Four high-heeled shoe and foot-apparatus prototypes are presented as series of case studies; *Pre-prototype (BipedShoes)*, *Computer Enhanced footwear Prototype 1*, *Computer Enhanced footwear Prototype 2* and *Computer Enhanced footwear Prototype 3* (from now on I will refer to these prototypes as *CEF P1-3*). These works belong to the overarching field of NIME (New Interfaces for Musical Expression), integrating theatrical fashion approaches to costume the foot for performance. There are always challenges to address for an artistic act or object to exist and change over time. To address these challenges, I developed a personal artistic method, which I will unpack in the next section.

The four prototypes described in this chapter explore the following research questions.

1. How can digital technology embedded in high-heeled shoes and foot apparatus change what we can do with feet?

2. What are the design techniques for computer-enhanced foot apparatus/high-heeled shoe-based digital musical instruments that facilitate unusual audiovisual theatricality, expression and experimentation?
3. What cross-disciplinary approaches can be used to develop *computer enhanced footwear*?
4. What are the artistic opportunities of *computer enhanced footwear* and using our feet in different ways?

4.2 Artistic Method

The development of the foot-based prototypes follows a personal artistic method. Each artist has a unique way of creating their work. My artistic method builds on understandings gained from my group Chicks on Speed (COS) and involves experimental, reflexive and cross-disciplinary approaches to enrich my investigations throughout the prototyping process. From ideation, iteration to performance—the practice-based research I do extends and surpasses my expectations with each project I undertake.

An important factor of my personal artistic method has been finding and immersing myself in unique creative climates and state-of-the-art laboratories. As such, I have developed my research and prototypes through a series of artist-in-residencies and ArtScience research fellowships at universities, art institutes, corporations and fabrication laboratories. These experiences informed conceptual and material directions and provided me with opportunities to work with an array of experts who have influenced the trajectory of my research.

In my personal artistic method everything is interconnected, like in a 'gesamtkunstwerk'[111]. For example, when conceiving my foot-based instrument prototypes, my objective is to encompass these interconnected qualities:

- Musical instrument
- Fashionable costume[112] for the feet

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[111] See Appendix E: Definition of Terms.
[112] See Appendix E: Definition of Terms.

- Prop
- Deconstruct and redesign high-heeled shoe
- Bespoke (non-market)
- Novel handcrafted 3D printed material
- Bring attention to our feet
- Provide unique musical playing techniques
- Encourage extranormal audiovisual foot expression and theatrical engagement
- Opportunities of artistic creation led by the feet
- Styling element for editorials, media and stage
- Metaphorical – agency.

This artistic method I speak about in this thesis merges fashion, sound, performance and digital technologies to create a different type of costuming for the foot—one that alters our perceptions of shoes and feet and which surprises and engages with audiences.

My work promotes the use of foot appendages to create an audiovisual spectacle and create a sort of momentary 'climax' within a performance. I do this by making bespoke foot costumes and taking 'ready-made'[113] high-heeled shoes and practicing 'demaking' or 'making strange'[114] to transform the shoes into visual/musical instruments.

By replacing the heel of an identifiable high-heeled shoe with a tailored 3D-printed heel (which includes space for circuits and sensors), my method turns the high heel into a 'technical apparatus' (Flusser 1985) and challenges the way people think about the shoe and what it can do. The process subverts the high-heeled shoes' original fashion-commodity connotation and consumer preferences for fast fashion and 'reinvestination[115]' (Meinhold 2014). It also extends the body and foot's artistic performativity—facilitating a 'wearable performance' element in a specific scene of a

[113] See Appendix E: Definition of terms.
[114] See Appendix E: Definition of terms.
[115] Roman Meinhold in his book *Fashion Myths* terms this 'philosophical-anthropological'; an account of fashion as something that is a commodity promising the individual an art of living by selling signs and symbols of values which go beyond the physical artefacts themselves and are nothing more than 'fashion myths' (Meinhold 2014) promising youth and eternal life, through constantly updating and changing ones clothes, he sees fashion as a staging of the self; with its 'melioration' (Meinhold 2014) being a form of improvement and aestheticisation (Meinhold 2014 / Smelik 2016). In this thesis I use this term to describe many people's obsession with footwear and footwear having the power to 'stage the self' or make one feel different, younger or play a character as discussed in section 2.3.

larger show (Birringer & Danjoux 2010)—something audiences are not necessarily used to seeing.

My method is not purely concerned with virtuosity through the way the shoe artefacts have been physically made, performed or documented via a lens. Instead, the research is more concerned with radical artistic exploration, going 'off-piste'[116] and giving space to the unusual, unpredictable and strange processes and outcomes which are sometimes out of one's control when working in a bigger art collective like COS. Therefore, my exploration of ways to use the feet and 'demake' high-heeled shoes or foot apparatuses has embraced DIY[117] aesthetics and spontaneity. For example, sometimes we performed in dark night club spaces with the shoes, without professional camera people, working instead with an enthusiastic audience member with a mobile phone to capture the happenings on stage. I believe such documentary material is just as valid as performing in a museum with a professional AV team.

As such, in this chapter, both DIY and high definition lens-based documentary case studies are presented.

4.3 Prototyping

The prototyping I undertook during this project developed from work I did with sounding high-heeled shoes with my group COS as described in section 2.2 Artists Background. My interest lies in how foot-based audiovisual instruments can be developed to afford extranormal[118] movements, look good (or bizarre) and affect dramaturgy in a performance. This requires a prototyping process that considers not only technological but also conceptual, historical, philosophical and aesthetic issues. It also relies on reflexive and experimental practice such as Schön's method of reflection-in-action (Schön 1983) and exploring performance during fabrication stages.

Depending on the context, I refer to the prototypes as computer enhanced foot apparatus (*CEF)*, foot apparatus, foot-based instruments, foot appendages, sounding

[116] Off-piste skiing is not done on the marked pistes (=tracks) but on fresh snow that has not been skied on (Macmillan dictionary), this can be compared to going off-road into un-road mapped territories.
[117] See Appendix E: Definition of Terms.
[118] See Appendix E: Definition of Terms.

high-heeled shoes and shoes. The formal names for my four key physical prototype projects are outlined below.

Physical prototypes:

1. *Pre-prototype (BipedShoes)*
2. *CEF P1*
3. *CEF P2*
4. *CEF P3.*

I believe an approach dedicated to the integrated understanding of the whole (Jorda 2005) is the key to achieving better creative results in the design and prototyping of wearable audiovisual instruments. It's not just the musical instrument that's important. It's also the interconnected understandings of the prototypes and their relationship with the entire theatrical performance or gesamtkunstwerk and the different types of documentation and outcomes that result from this process.

As described by Granata (2017), recordings and documentation of such performative acts (which I suggest also includes the performances of making in the fabrication laboratory) are new found artistic opportunities and can "constitute a primary source of a similar order to the garments themselves" (Granata 2017, pp. 12). In the process of developing the four foot-based prototypes, I achieved the following artistic outcomes and opportunities:

- 200 performances, keynote presentations and screenings with the *pre-prototypes (BipedShoes)*, *CEF P1*, *CEF P2*, *CEF P3*
- 3 Live-Art video works with *CEF P1* and *CEF P3*
- 7 lens based works with *CEF P1*, *CEF P2* and *CEF P3*
- 2 self-directed music videos featuring *CEF P3*
- 1 Fashion Tech show where I was art director and performer with *CEF P3.*

Rather than present all of the above-mentioned artistic outcomes and opportunities, I will instead present the following selection in this chapter:

- 20 performances with *pre-prototypes (BipedShoes), CEF P1*, *CEF P2*, *CEF P3*
- 2 Live-Art video works with *CEF P1* and *CEF P3*
- 5 lens-based works with *CEF P1*, *CEF P2* and *CEF P3*
- 2 self-directed music videos featuring *CEF P3.*

4.3.1 ArtScience collaborations

A large part of my research project is built on strong collaborations[119] with technologists, scientists, performers, musicians, dancers, composers, choreographers, sports scientists, shoe makers, computer scientists and small to medium enterprises[120] whom I worked closely with at various stages of this research. The ArtScience collaborations took place in artist-in-residence programs in scientific organisations and corporations. These collaborations reflect working on a common goal to create something new which may not be achieved by a single mind (Candy & Zhang 2007).

For the collaboration with the technologist and computer scientist, the idea was to build new technical systems to facilitate new types of artistic audiovisual expression. My main collaborating engineer and technologist throughout this research was Sam Ferguson on the *Pre-prototype (BipedShoes), CEF P1* and *CEF P2. CEF P3* was developed in partnership with ProtoPixel engineer Daniel Gallardo Grassot and Reactable Sound Systems co-founder and owner Sergi Jorda and technologist Pere Calopa Piedra. Aside from this, I carried out additional technical system development and machine learning experiments of *CEF P1* and Stretchsense stretch toe sensors with computer scientist Rebecca Fiebrink, inventor of Wekinator[121] (machine learning software for artists). I also collaborated with artist and scientist Steve Mann on a series of lens-based works and video

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[119] For the full list of collaborators credits, Appendix F: Project Acknowledgements.
[120] Creative tech-transfer partnerships with small to medium enterprises (SME's) alongside the AIR's were an important part of creating the physical prototypes. They provided access to state-of-the-art sensors and systems (light and sound). A lot of the time, such hardware and systems aren't even out on the market, so the only way to get to use them is by creating collaborations with the company, offering to test it out and give them marketing material and public exposure in return. Such collaborations offer a transfer of technology to new audiences with a level of creativity and public exposure the companies cannot achieve alone, so it's a good trade-off for both myself and the collaborating tech start-ups.
[121] For more information: www.wekinator.org

documentation pieces during the fabrication of the *CEF P3* at Autodesk, Pier 9 Technology Centre, San Francisco[122].

4.4 Prototype Case Studies

4.4.1 Pre-prototype (BipedShoes)

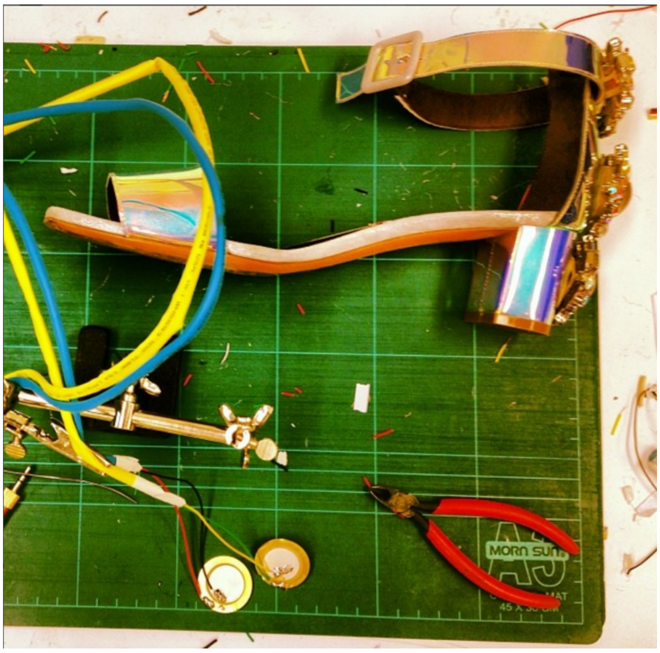

Figure 54. *Pre-prototype (BipedShoes)*. Ready-made Bruno Magli shoe with piezo pick-up microphones.

The *Pre-prototype (BipedShoes)* was an initial experiment to kick-start my research with *Computer enhanced footwear* prototypes, where I set out to explore questions including:

- What sounds can be coupled together with foot-based costumes? How can this encourage playful, performative interaction and choreographed sound?

[122] https://www.autodesktechnologycenters.com The Autodesk Pier 9 Residency brings together artists, start-ups, companies and academics under one roof with Autodesk Research to explore technologies that contribute to the factory of the future.

- In what ways does the use of sounding foot-costumes change what we usually do with our feet on stage in live performances?

Traditionally, the primary purpose of clothing or fashion as a stage costume is not making sound, especially in a musical sense. However, many items of clothing are in fact inherently associated with characteristic sounds. For instance, the sound of a zipper is associated with the action of opening and closing a fashion item (such as a bag), the rustle of a raincoat or the opening of an umbrella heralds the rush into rainy weather or the hurried escape from it. And of course, the sound of a high-heeled shoe is a characteristic warning of the approach of a taller-than-normal person (Murray-Leslie & Ferguson 2015). The use of these pre-existing sounds within a performance context is a fertile situation for an acoustic foot-object, but also allows the sound's associated visual or choreographic metaphors to be subverted for performance purposes[123].

Ready-made Bruno Magli shoes[124] were fitted with piezo contact microphones on the mylar coated inner heel of the pump-like shoe (see Figure. 54), which supported strong vibration when the heel hit the floor. Telephone wiring was stripped and soldered to a mini jack on one end and on the other end, the cable was split and soldered to a piezo. The audio cable ran up the leg of the pants or tights of the performers and connected to a wireless mic sending device, worn on a belted waist. The analogue audio signal was transmitted to a wireless microphone receiver and dedicated channel. Each audio signal channel was routed to a Max/MSP patch where the signal values were converted to data-values. Each of these data channels from the performers was mapped to various parameters in FM synthesis (frequency modulation synthesis).

My objective was to be able to hear the shoed 'human' foot step and a trace of 'synthetic' sound (sonic shoe echo), which represented the 'technology' creating a unique kind of 'human computer interaction'. This was done by mapping the real-time flow of data to frequency modulation synthesis parameters and leaving the original analogue sound to come over the PA system. The data was thus used for generating spontaneous,

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[123] Chicks on Speed used sound samples of walking in high-heeled shoes, in a metronomic way to create the introductory beat of the song 'Time Ripples' https://www.youtube.com/watch?v=TlQJVjSax7w
[124] Italian shoe and leather wear brand Bruno Magli (creative director Max Kibardin) was my fashion industry partner in this project and designed the shoes and costumes specifically for the Prototype Hits performance work. The garments were coupled with banners I designed, which I describe in the next chapter.

unusual new sounds in combination with the microphone audio. The new sounds were assigned to five pre-sets in Max/MSP, one for each performer's sonic shoe echo.

4.4.1.1 Prototype Hits workshop

Bon Marche Theatre, The University of Technology, Sydney, 12-14/09/2013.

Prototype Hits set out to investigate the rethinking of foot movement to sound composition (choreographed sound) by using technology to respond to movements made by performers wearing miked up shoes and holding monochromatic textile banners[125] (see Figure 55.) in connection with camera vision[126]. These banners were used by the performers as costumes that changed into sonic-architectural shapes in space, depending on how the performers improvised individually and together as an ensemble with the banners whilst moving their feet.

To begin investigating the research questions of this thesis, a series of workshops into shoe acoustics were conducted to explore the relationship between performers and footwear coupled with sound. Through the workshop and 2 associated performances, I aimed to find a new language of movement-based sound to define shoe acoustics as relevant to new and unknown artistic practices with the feet and high-heeled shoes, their techniques and procedures in theatrical performance. The process-based workshop (based on improvisational processes, open to real-time experimentation), took place over seven days, between artist researcher, technologist, movement advisor, five dancers and a design firm[127].

At a high level, the following methods were explored:

- Performing interactions: building bodysculptures with sounding footwear and musical coloured textile banners (see Figure. 55), a convergent practice of body, architecture, sound and costume.
- Sounding footwear affords interpretation to build an individual foot language:

[125] In terms of the implementation of the textile banners as acoustic costumed object, the banners were used as a source of movement data by colour tracking each of the five colour 'patches' with a single camera positioned and focused on the middle of the stage. The size and location of the banners were mapped to a simple algorithmic sound generation process based on aleatoric techniques, which was passed to several instances of a polyphonic synthesizer (one instance per performer), so that each of the performers had control of a 'voice'. The size of the banner, specifically, had control of the pitch of their voice. As they folded their banner, making their patch colour smaller, lower pitch tones were produced, and conversely, as they unfurled the banner, higher pitch tones were produced
[126] Textile banners were a separate musical instrument, upper body costume to the shoes and I won't go into too much detail, as the focus of this research is on sounding footwear, however it's important to note that in most cases an outfit is usually presented with a pair of shoes.
[127] See Appendix E: Project Acknowledgements

- Word action ~ each performer responded to a metaphorical spoken word, enacting it with their bodies, feet and textile banner.
- Sonic reflection ~ this describes the microphone capturing the performers' choreographed foot movements and processing of the sounding choreography into data and being mapped algorithmically to different parameters in FM sound synthesis in real-time. In effect, each movement with the shoes had a corresponding sound 'reflection' or sonic shoe echo.
- Reaction ~ the performers 'reacted' to the sounds they heard and went on to improvise the next choreographed sound. The reactions turned into improvised costumed acoustic bodies in space, resulting in a series of 'body-envelopes' (bodies enveloped in coloured cloth, together with the shoes and their acoustic reflection). The performers tuned in and out of each other, forming part of an interactive dialogue between performers, and building a collaborative body-sculpture (see Figure 55).

Figure 55. *Pre-prototype (BipedShoe)* and banners performed as bodysculptures by dance troupe *The Lycra Ladies* during workshop sessions 12-14 September 2013.

Workshopping began with using metaphors to stimulate dancers moves. 'Remote-controlled shoes' represented the human being led by pre-programmed algorithms, embedded in the 'out of control' shoes. Whereas the words 'malfunction' and 'latency' described technology going wrong, failing, being delayed, out of sync or otherwise imperfect. Performance instructions[128] based on these metaphors were given to the dancers and they responded with physical interpretations.

Performers were free to interpret the metaphor as they desired. Simultaneously, we (technologist and artist) observed the movements of the dancers and experimented with FM sound synthesis mappings in real-time, deciding on a sound palette as we went along. The concept of multimodal synthesis was adopted as a methodology and carried out in the designing of each scene, i.e. a synthesis between the foot costume, body movement and sound.

Figure 56. *Pre-prototype (BipedShoe)* performed by dancers during the song *Prototype Hits* at *Prototype Hits* Live performance, *SEAM: Authorship, Curation, Audience Conference*, Critical Path, The Drill Hall Sydney, 16 September 2013.

[128] Fluxus artists like Yoko Ono or Dick Higgins, in his 1960s Gravis performances (1965). Drawing on Ono's and Higgins's methods of instructional performance.

The dancers interpreted the instruction/metaphor ‘remote-controlled shoes’ in numerous ways; some used repetitive foot motions, others acted as if the shoes were leading them with the dancers’ bodies rendered helpless (yet looking aesthetically interesting and extranormal) by the machine-made shoes controlling their jerky, awkward movement and feet in the air (see Figure 56.). Such a metaphoric movement experience can quickly also conjure up notions of women’s high-heeled shoes as fetish objects or must-haves in the world of fashion, where women go mad to have the latest ‘it-shoe’, or where the shoes control the wearer on a high-speed catwalk out of control.

Each shoe augmented with the contact microphone and outputs of the five wireless systems (one per performer) were processed via the MaxMSP patch, using two sets of processing that could be mixed together. The first processing method was a set of simple resonant low-pass filters, allowing each of the performer’s shoes to be given different characters. The second processing method was a vocoder, which was used to give the shoes a synthetic or ‘granular synthesized’ sonic character. Following these processes each channel was mixed with different pan values down to stereo.

The playing of the shoes with the feet explores the spontaneous, non-virtuosic, unrepeatable way of playing foot based musical instruments, which is different to performing classical musical instruments or tangible post-digital musical instruments with the fine dexterity of the hands. As discussed in section 2.3, the feet usually perform functions of support and locomotion and the hands of grasping and manipulation and this thesis seeks to reverse these roles. Taking this role reversal into account, it’s my objective the feet should be used in a different way and play a musical instrument in a different way to the hands.

I had a realisation at this point in my research, informed by the background literature—I realised technically enhanced shoes took on agency[129]. This can be compared to the ruby red shoes in *The Wizard of Oz*, other fairy tales and social scientific research as discussed in section 2.4.1. Like Fairy tales, which use shoes as metaphors of expression, I was doing the same thing with the *Prototype Hits* workshop experiments by embodying metaphors such as ‘remote-controlled shoes’ to transform the wearer into something else.

[129] See Appendix E: Definition of Terms.

This breakthrough opened me to new artistic opportunities led and made by the feet. In the following section I describe some artistic outcomes using the *Pre-prototype (Bipedshoes)* where I tested the shoes inside two public performances.

4.4.1.2 Prototype Hits Live Performances

I directed a 20-minute scene using the *Pre-prototype (Bipedshoes)* as central protagonist, with five dancers, costumes and a song titled *Prototype Hits* (see Figures 56. and 57. below). The scene was performed at the following events:

- SEAM: Authorship, Curation, Audience Conference, 16-17 September 2013, https://vimeo.com/murrayleslie/preprototype-seam-conference-sydney.
- *Jamaramma* curated by Chicks on Speed, Artbar, Museum of Contemporary Art Australia (MCA), 28 February 2014, https://vimeo.com/murrayleslie/museum-of-contemporary-art-australia

For the performance at MCA, the shoes accompanied our COS song *We are Data*, with the shoes providing a sort of malfunctioning hard drive metaphor in their choreographed sounds and movements that were played over the backing track of the song. The five pairs of sounding shoes got louder towards the end of the song and eventually only the sounds of the low pass filter and vocoder were heard. The dancers provided the grand finale to the performance. Led by their feet, they climbed the stairs and exited the stage at the end of the song accompanied by the sound of solo amplified foot-steps trailing off with random digital popping and crackling sounds (sounding like analog synthesizer anomalies).

Figure 57. *Pre-prototype (BipedShoes)* performed with the song *We are Data* by Chicks on Speed, Museum of Contemporary Art Australia, 28 February 2014.

The initial prototyping specific themes discussed in 4.4.1 *Pre-prototype (BipedShoes)* lead to these insights:

- What sounds can be coupled together with a sonic foot-based costume and how can such a visual acoustic shoe affect the performer and what they can do with their feet?
  - The sensor (piezo (-) MaxMsp) enhanced the shoe and changed the way we moved. The fact that the shoe was technically enhanced and interactive gave the shoe a kind of agency, as the performers related to it in a different way than a pair of shoes without sounding potential.
  - Assigning FM synthesized sounds (vocoder and low pass filter) to the acoustic shoe instruments in real-time meant that each movement with the shoes had a corresponding personalised sound 'reflection' or sonic shoe echo. The sounds from each individual performer were unique, in the same way that the sound of an individual's footsteps reflects their personal gait.
  - Costuming the feet as musical instruments affords individual and extra-normal movement of feet.

- Such a hearable costume for the feet facilitates different role playing of performers, like the metaphor 'remote controlled shoes', adding poetic meaning to a scene.

- How can a performer use fashion inspired foot-costumes to make sound?
    - The use of sound in the performance-based research context was a fertile situation for an acoustic foot-device costume, but also allowed the sound's associated visual or choreographic metaphors to be subverted for performance purposes. When performers were given the chance to experiment with these 'natural user interfaces' (Mann 2007) for musical expression they built up an audio-visual language as repertoire. I term this 'choreographed sound'.
    - Personal artistic processes working on this prototype included Synetics and instructional performance strategies[130], I was using some of those techniques[131] to assist in answering the research questions.

Analysis of practice

- Sounding footwear costumes can act as an accessory, prop or styling element to a song, like a watch, jewellery, handkerchief or gloves.
- Through designing analogue/digital components attached to shoes it's possible to transform the existent practice of performers and their feet to:
    - Encourage a performer to use their shoed feet in a different way.
    - Offer the wearer new ways to perform in ways that other shoes don't, e.g. interactive shoes that make two types of sounds (natural sound of shoe coupled with the FM sound synthesis sound or sonic shoe echo) encourage performers and dancers to perform actions they usually wouldn't, reacting to the sound of the shoes, like sliding the foot or stepping harder on the floor than they usually would as a different sound was triggered through this action.

[130] William Gordon's Synetics research from 1961, analogies or metaphors were suggested to performers, who interpreted them. e.g.: I asked the performers "what would I feel like if I were a shoe" putting themselves inside the object, the performers reacted with poetic movements interpreting how shoes might move and sound.

[131] Aanalogies, compared to the instructions given to performers in instructional Fluxus performances such as by Dick Higgins (1960) Gravis performances – formed a starting point to the workshop by beginning with a word, that could signify a poetic gesture with the amplified shoes, we decided upon 'remote-controlled shoes'.

    - Almost develop a new walk for themselves. Through analogue and digital technology enhancements, the *Pre-Prototype (BipedShoes)* became interpretative appendages with manipulation qualities (or in this case 'pedipulation').
- Dragging the foot, vs stepping on the heel. It was interesting how these things became part of the shoe instrument (something that usually wouldn't be interesting with an everyday pair of shoes).
- Providing a digital intervention to ready-made shoes, extended the foot's unseen peripersonal space[132] through choreographed sound. Sound extended performers' range of motion with their feet leading them to be more conscious of their feet.
- Energetic synthesis between the feet and sound through a shoe costume.
- Hands are usually playing musical instruments and not feet as there are more musical instruments made for the hands than there are for the feet. The feet usually balance a performer whilst the hands play an instrument.
- The focus of the audience moved from the hands to the feet during the performance on stage adding an element of surprise, as the feet are usually obscured by fold back speakers.
- Unusual Musical instruments for the feet change over time:
    - You discover different aspects of the instrument through performing with different performers in small groups. Each performer uses a foot instrument differently. This was shown by each performer having a different way of interpreting the three metaphors and the sounds we connected with their foot movements.
    - To resolve an instrument for the foot, it's interesting to build the instruments physical/acoustic designs over time as we can use our feet in so many ways, that we're not used to doing. So we need to practice this sort of foot expressivity and see how the design can adapt to the 'speaking' foot.
- Costuming the foot for audible sensory perception extends meanings of everyday shoes:

[132] Peripersonal space is the immediate space around one's body or feet in the context of this thesis.

- Addressing building a ‘Natural User Interface[133]’ comparable to haute couture[134] or a bespoke costume made for a specific character on stage, developed around an individual character’s needs, like a costume. The shoes and costume were connected in the performative statement they were making (the shoes sounded and looked like remote controlled shoes; visually due to the visible technological elements (audio cables, piezo microphones, radio transmitters) and physically by means of the dancer’s chosen movements in response to the metaphor ‘remote controlled shoes’.
- Personal gestures of a player can be represented in their own acoustic resonance or traces. Each individual performer walks and moves in shoes differently, the challenge is to amplify these personal acoustic traits to make them more perceivable.
- Supporting improvisational interaction (building audio-visual body sculptures[135] see Figure 55) with other performers extends the visual costume into the medium of audible sensory perception.

Reflections

I’ve demonstrated through the workshop and live performances that performing foot costumes was a distinctive way for the dancers to embody the acoustic shoe instruments through personalised foot movements (something dancers wouldn’t usually do with their feet). Through instructional performance strategies, as an artistic method, both the sounding foot costume and FM Synthesis sounds were combined and expressed through movement actions.

Through the use of foot costumes and metaphors, there was an instance when shoes, legs and body coupled with the FM synthesized sounds and took on a new physical meaning in the performance without an instruction being called out. It manifested out of a natural improvisational series of movements which surprisingly led to a new audiovisual

[133] Troy (2003) in her book “Couture Culture” links fashion with modern art, describing fashion as having been equal to painting and music, with its makers working hand in hand with composers and painters to craft an all-encompassing work of art and zeitgeist (spirit of the times, the intellectual fashion or dominant school of thought that typifies and influences the culture of a particular period in time). Haute Couture is ‘high sewing’, ‘high dressmaking’ or ‘high fashion’ and refers to the creation of exclusive custom-fitted clothing (Wikipedia 2013).
[134] See Appendix E: Definition of Terms.
[135] *Bodysculptures* were created a lot on stage with Chicks on Speed, in relation to the *Eshoe* and other *Objectinstruments*, as example is in the book *Chicks on Speed; Don’t Art, Fashion, Music* from 2010.

language depicting the 'body as antenna'[136] (observed by the performers). The body took on the metaphorical guise of an antenna and began scanning the surroundings, (influenced by the sounds emitted by the *Pre-Prototype (BipedShoe)* instrument) as if looking for precious metals, looking and sounding like a metal detector.

The process revealed design shortcomings that would need to be improved in future designs. For example, the mic sender on the belt was heavy and bulky (see Figure 58.). This affected free movement and didn't work well with being part of a seamless foot costume. Though the cables were an interesting styling element, they also impeded on the performer's movements (a wireless circuit/system inside the heel of the shoe would be necessary in the next iteration).

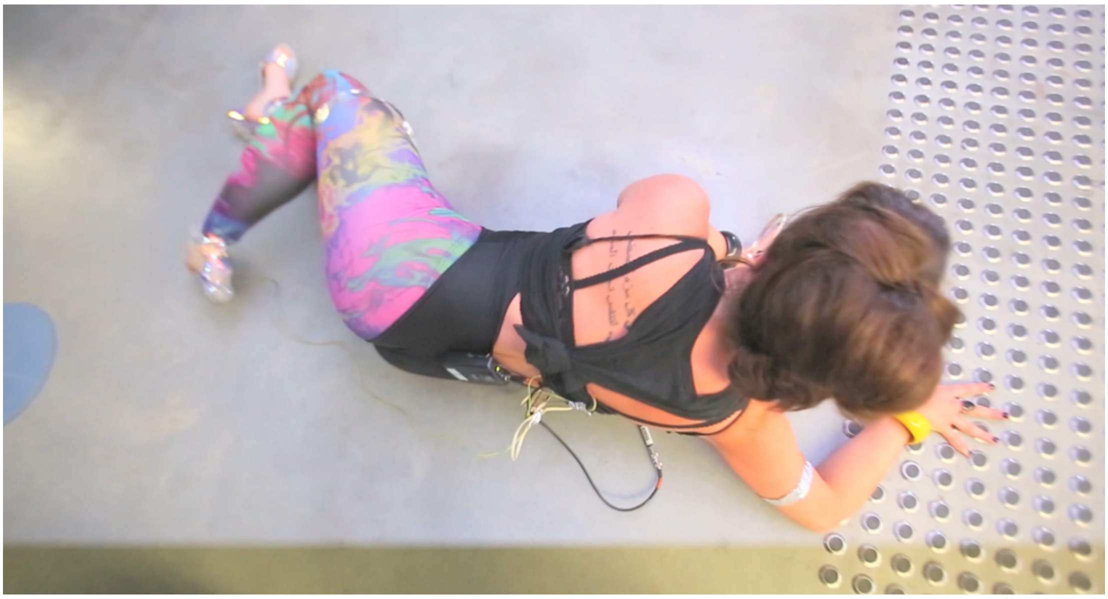

Figure 58. *Pre-prototype (BipedShoes)* performed by *The Lycra Ladies* to the song *We are Data* by Chicks on Speed, Museum of Contemporary Art Australia, 28 February 2014.

[136] This new metaphor 'body as antenna' discovered through working with the *Bipedshoes* was further explored and interpreted in enacting of shoes (visually performing the metaphor and sonically representing the concept in the sound track) in the Chicks on Speed film *Golden Gang* and several scenes where the golden shoes become both metal detectors and or the 'body as antenna' concept is channelled in the character movements: https://vimeo.com/chicksonspeed/goldengang (password: lycraladies) scenes; 'scanning for gold' 1.30 minutes and 12.21 minutes. I use these 2 example to show that the experiments I was conducting in this thesis fed back into the gesamtkunstwerk of Chicks on Speed. I see my work in isolation in this thesis purely as a way to facilitate new research and experimentation with foot based musical instruments, the pieces remain un-finished until they go back into the larger art, film and live performance works of COS, where the shoes are interconnected inside a larger artistic production (in connection to a song or scene) the shoes tell one micro-story in the bigger picture.

Having the feet lead the dancers out of the stage area was a strong way to finish the show. It added a surprising climax and worked well conceptually. Seeing the performers jerking on the ground moving in a dysfunctional way accompanied by sounds mimicking their moves (stuttering vocals and resonating intermittent crackling and pops) resembled a malfunctioning body led by technology or ‘remote controlled shoes’.

The *Prototype Hits* workshop and performances created a collection of unstructured garments, made up of asymmetrical silhouettes and time-based ascending and descending acoustic tones to match. Like nail polish or a hand bag, the sounds complemented the ‘new listening look’ or ‘the sound of fashion’ like props or styling elements. It was through the performer’s interactions with the shoes and coloured banners in unique formations (bodysculptures/body-envelopes) that choreographed sound compositions were strung together. The *Pre-prototype* (*Bipedshoes*) successfully echoed the sound of a foot costume through amplification and transformation of the acoustic sound.

What also became interesting about this piece was how the artist/technologist responded to the concept of ‘remote controlled shoes’ in real-time. Performers enacted instruction collaboratively, while simultaneously listening to the uniquely mapped FM synthesised sound.

Overall, *Pre-prototype (BipedShoes)* presented the theatricalisation of a shoe through interconnected digital, analogue musical instrument, fashionable costume and choreographed sound elements. The project helped me realise it is possible to exert a sense of theatrical being through a foot costume and influence a new visual and sonic language through the feet during performance.

While *Pre-prototype (BipedShoes)* fell short of continuous iterations, they acted as an intermediate stepping stone for the *CEF* which I present in the next case studies.

4.4.2 Computer Enhanced Footwear Prototype 1

The *Computer Enhanced Footwear Prototype 1* (*CEF P1*) is a further iteration of the high-heeled shoe instruments as discussed in the artist's background sections 2.2.3 and 2.2.4 and builds on insights gained working with *Pre-prototypes (Bipedshoes)* as discussed in the previous case study section 4.4.1. The *CEF P1* set out to explore questions such as:

- How can computer enhanced shoes that make sounds and are played in the air, prompt a performer to use their feet different ways?
- What could be an appropriate language of the feet (taxonomy of gestures) with computer enhanced high-heeled shoes?
- How can the movements of shoed feet (taxonomy of gestures) be sonically represented through FM sound synthesis mapping strategies?
- What are the possibilities to perform sounds with the feet, whilst moving and singing a pop song or playing the shoed feet in an improvisational setting with other musicians?
- How can *CEF* de-construct the iconic high-heeled shoe and change it from being something torturing, accessorising or superficial into a new musical instrument for foot based artistic expression?
- What circuits and sensors can be used (based on Paradiso's footwear prototypes, discussed in section 2.7) and how these can such circuit/sensing footwear impact physical design and performance?
- How to design and construct a sensing 'technologised' heel to suggest different kinds of movements of the foot via a stream of data?
- How to build a 'natural user interface', a bespoke costume for the foot, that is developed around an individual player's needs?

4.4.2.1 First steps

Starting with simple line drawings of the appendage without an upper (see Figure 59.), *CEF P1* in its beginnings was more a conceptual aesthetic idea, attached to the foot in a temporary way. The design was informed by Laurie Anderson's lyrics of 'high-heeled feet' (see section 4.4.2.4.) as well as Jeremy Scott's 'Body Modifications' (see section 2.4.1) and Martin Margeila's conceptual approach to deconstructing a shoe (see Figure 91.). Both of these artists discussed in section 2.4.1. re-consider shoemaking by using materials to express direct concepts such as 'sick feet' and 'foot deformers'.

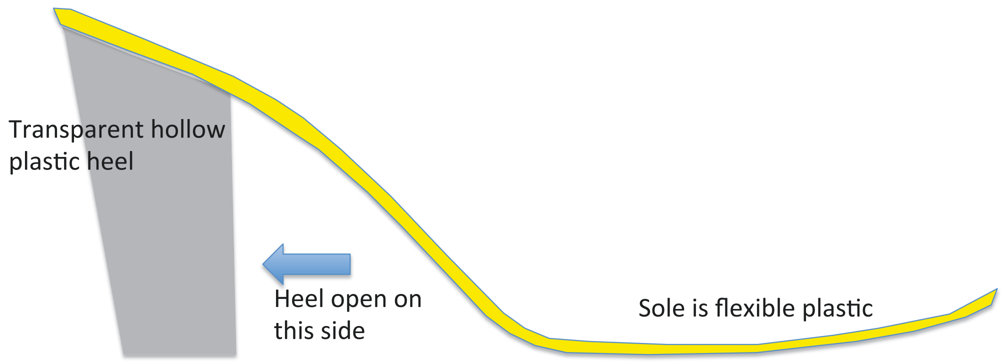

Figure 59. De-constructed shoe, first rough sketch of 2D sole design for interpretation in 3D design.

Drawing from Margeila, I was interested in deconstructing the shoe and using the minimal support structure of the shoe, the sole and heel. However, unlike Margeila, my design would have exposed technology inside the heel and would be more than just a shoe.

I continued the process by 3D printing model renderings (see Figure 60.). The prints for the most part, were unsuccessful, as I had no idea about shoe engineering, forces of the feet or what support the foot required from a shoe sole. I was really working in the dark but I was determined to get a momentum going with my prototyping process of learning by doing, making mistakes and iterating as I went along.

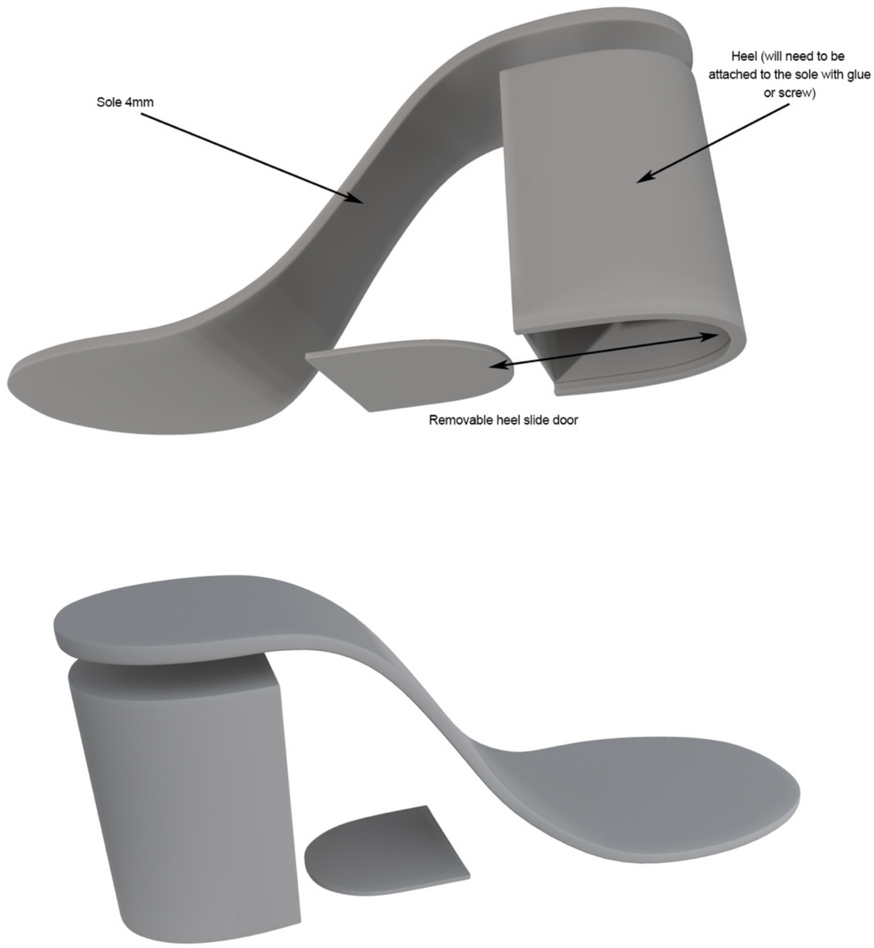

Figure 60. Deconstructed shoe, 3D rendering, showing heel compartment for the circuit. The arch area of the shoe is completely wrong, when looking the horizontal profile at the top of the heel.

Looking back on the process, I should have chosen the circuit board and sensors first, soldered them up and then designed the heel around them, to fit. Instead I started with the half shoe prototype, which led to a clunky heel that had no relationship to the circuits and sensors.

4.4.2.2 Sensing the heel

Contemplating the types of sensors available, I considered using the following sensors: accelerometer, gyroscope, magnetometer, FSR (force sensitive resisters), compass, ultrasound, geophones, stretch sensors, pressure sensors and microphones, contact microphone piezos, IMU's (inertial measurement unit). Referring to the literature as presented in section 2.6, I analysed what other artists and inventors had used in the way of sensors in foot and shoe prototypes and what types of sensing was possible to get from the foot, heel and shoe.

Joe Paradiso's 'Expressive Footwear' controllers to drive synthesizers during computer-augmented dance performances (see Figure 51. in section 2.8) were the most comprehensive interactive shoes with the most sensors to date. I drew from Paradiso's work and studied options of sensing and actuation that utilised existing sensor technologies (I obviously wasn't going to be inventing my own sensors). Paradiso had utilised all available sensors (primarily accelerometers) and types of data acquisition available to him at the time. For my design, newer senses would be smaller and enable me to embed them in a more seamless way than Paradiso had (see Figure 52. For an example where he attached a large circuit board to the side of the Nike Kimbia).

I also looked at the way Paradiso worked with the dancer[137] on 'Cyber Shoe'. For this work, he used a dual axis accelerometer, measuring tilt, velocity and the jumping movements of the foot, while the dancer was jumping intermittently and then walking again on the ground. From this, I decided there was room for new exploration using a computer enhanced shoe in aerial mode, instead of on the ground.

For this project, I was interested to find a circuit board and sensors that would be reliable and look good mounted into a 3D printed heel which was attached to a pair of ready-made[138] high-heeled shoes. It was important for me for the heel and its technology to be in proportion, so a person could recognise the design as a revamped heel. There were some constraining factors in selecting the initial board and size of sensors. I was careful not to go radically small, as the smaller the battery would provide less power. In the end, I selected an Arduino FIO and soldered it to a pololu minimu 9 V3[139] with integrated accelerometer, FSR (force sensitive resistors), giro and compass, XBee wireless module and a 3.7-volt lithium polymer battery (500mAh) (see Figure 61.). I opted to use an XBee as sender as my past experiences with radio in the first *E-shoe* showed it never broke mid performance. Whereas I found osc bluetooth to be unreliable, especially when

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[137] Article about the *Cyber Shoe* and experiments with dancers: The CyberShoe: A Wireless Multisensor Interface for a Dancer's Feet http://cba.mit.edu/docs/papers/98.11.IDAT98_Shoe.pdf
[138] See Appendix E: Definition of Terms.
[139] I later upgraded to V5, as after four years of performing with the V3, the conductivity was worn away at the solder joins.

there were several mobile phones at performances, sometimes the signal could be lost altogether

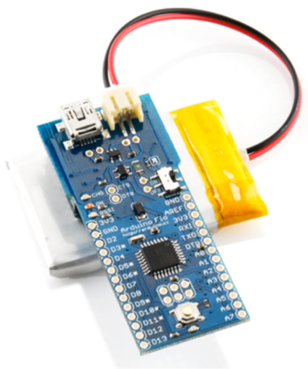

Figure 61. Arduino Fio Circuit board, ExBee, Minimu 9, V3 and lithium battery.

4.4.2.3 Demaking the High-Heeled Shoe

High-heeled shoes (see Figure 62. bottom right shoe) made to measure by Max Kibardin[140] (who was also my collaborator on the E-Shoe discussed in the artist background section in section 2.2.4) for Melissa and I for COS performances seemed to be an appropriate start to deconstructing a high-heeled shoe, then reconstructing it with additive fabrication technology. I also used these shoes as they resembled typical fashionable high-heels and I knew they would fit our feet. Using these shoes also helped to keep things cost effective and helped move prototyping along more quickly.

I also chose a recognisable high-heeled shoe design that would synchronously take on the guise of a 'ready-made', as it had to be a readily recognisable sign to an audience (as the shoes would be used for 3-4 mins on stage, during a specific song). This was important for instant recognition of the audience as the high-heeled shoe relates back to how shoes have important cultural, religious and social significance (Demello 2009) as discussed in the literature section 2.1. This also relates to the discussion on Sofer in section 2.4.2. and the way props are ties to symbology which is connected to a larger field of semiotics in theatrical performance. The creative practice presented here, draws on aspects of this understanding of shoes in our society. I liken this process to 'demaking' [141] the high-heeled shoe (part of my personal artistic method described in section 4.2) in order to give shoes

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[141] See Appendix E: Definition of Terms.

a new purpose and inform new processes of making and new types of footwear that can allow for complex creative expression, rather than high heels crippling our feet (Johnston & Murray-Leslie 2017).

The use of a ready-made looking high heel also seemed a natural choice, in connection to the meanings of ready-mades in art history. Somehow it presented an interconnected triple meaning, where it was becoming a shoe sculpture, a shoe instrument and a fashionable costume shoe. I was also interested in this juxtaposition of humour and irony towards the fashion industry (me not being seduced by it or taking it too seriously and yet being totally fashionable whilst costuming the foot). Such a juxtaposition could make audiences look and think twice. This sort of twisting of meanings 'making strange'[142] or 'verfremdungseffekt' (Brecht 1936) works well in a theatrical pop frame from my experience, alluding to ideas and leaving things like props or song lyrics open to multiple interpretations.

Figure 62. Top Left: Original Bruno Magli high-heeled shoe. Below left: detached heel. Top Right: first 3D-printed prototype shoe. Bottom Right: Original Bruno Magli Shoe covered with white duct tape.

I recognised I had to redesign the heel and sole angle, as the angle at the top of the heel was not right for the foot bed (see Figure 62. top right shoe) and the heel width was not

[142] See Appendix E: Definition of Terms.

appropriate for the circuits. Having seen the heel was faulty, I took one of my Bruno Magli stage shoes and pulled off the heel (see Figure 62. bottom right high-heeled shoe).

Pulling the heel off my pair of stage shoes was a good way to learn about heel and shoe construction, as there was a way to reverse engineer it. I took a set of measurements and angles which were input into fusion 360 (CAD computer aided design 3D rendering program). I left an external pocket for the circuit with attached sensors, exbee and lithium battery on the outer edge of the heel. I 3D printed the heel in a standard white PLA (polylactic acid) print filament in low resolution, which was quick and strong enough to bear the weight of the wearer. A prototype can always be improved but it does not have to be perfect looking the first time around. That said, I also like the visual aesthetic of a 'prototype' (like the process-rich aesthetic of the *Pre-Prototype (Biped Shoes)* described in Section 4.4.1)—a finished design can also have the visual aesthetic of a prototype.

Figure 63. Original Bruno Magli shoe upper covered with duct tape, with 3D-printed heel, Arduino fio circuit and minimu 9 V3.

I chose white colouring for the shoes as the neutral colour white (achromatic) is probably one of the best choices to use on stage for a costume, as it reflects all the light on stage, making one's costume very bright and central in a performance. White also stands out against the usually dark stage backgrounds and really pops on stage. I also decided on white shoes because the feet and shoes are usually obscured on stage due to black fold back speakers and cables.

The upper of the shoe was coloured using white duct tape (see Figure. 63). Duct tape is a material commonly used on stage to tape down electronic instruments in windy outdoor situations or bouncy stages or to guide performers around dimly lit stages. Thus, this material holds a specific meaning, especially for those who are familiar with stage performance contexts. This gives the shoes the added meaning of being covered with something practical—a tool of the trade that is inexpensive rather than a decorative, expensive commodity in a store. Duct tape is also (usually) temporary, giving the *CEF P1* a more DIY aesthetic.

Analysis of practice

- In order to use the feet in a different way and identify types of sensing of the feet, the decision-making process was guided by the literature, specifically; *Expressive Footwear* by Joe Paradiso discussed in section 2.8.
- Using the feet in the air (as discussed in 4.4.2.2, which will be unpacked further in this chapter) coupled with sensor technology impacted the physical design of the heel which became a design feature and affords:
    - Communication devices of the feet:
        - the circuit via the exbee is communicating to a laptop and external PA system which the audience hears.
        - the sounds the shoes make in the air are different to the ground, they form part of an aerial sonic language of the feet.
        - just as the foot costume (as prop) expresses visual ideas as discussed in section 2.5.2 as a "tool to subvert the symbolism previously embodied by the object it represents" so too does the way of using the feet in areal mode coupled with the sounds the shoes make in the air, all these elements are interconnected and communicated via the foot costume played in areal mode.
- De-constructing the iconic high-heeled shoe became a subversive audiovisual statement.
- High-Heeled Shoes as prop:
    - Complex inter-relational aspects of *computer enhanced footwear* carry innate emotional expression and symbolism on stage.

4.4.2.4 High-Heeled Feet

> Well I stopped at the body shop
> I said to the guy, I want stereo FM
> Installed in my teeth,
> And take this mole off my back
> and put it on my cheek.
> And while I'm here
> why don't you give me
> some of those
> high-heeled feet
> -Laurie Anderson "Monkey's Paw"
> (Balsamo 1996, p. 18).

I rediscovered Anderson's song lyrics via Balsamo's (1996) seminal book[143] and made a series of interconnections between the prosthetic of Viktoria Modesta featured in section 2.4.2, Jeremy Scott's Foot-modifications from section 2.4.1 and Margiela's deconstructed shoe (see Figure 90.). Somehow reading Anderson's lyrics again led me to a breakthrough, how I could connect the elements embodied in each of the examples mentioned in the visual aesthetics of my version of a deconstructed shoe, which I'd attempted in the first rough drawing (see Figure 59.), I decided to make a high-heeled foot, embedded with technology.

To brainstorm the physical design, I experimented with kinesiology tape[144] (also known as kinesio tape, usually associated with a sports aesthetic, see Figure 65.) attaching the circuit embedded heel to the foot (see Figure 64.), This simulated a temporary appendage, dysfunctional shoe or non-market shoe (i.e. something that cannot be sold as a product, like a normal shoe). This is because I didn't want the prototypes to exist as products, but bespoke pieces; to subvert the original commodity of a high-heeled shoe, deconstructing it physically and politically. The use of kinesio tape refers to Scott's (see

[143] "Technologies of the Gendered Body: Reading Cyborg Women" (see references).

[144] Kinesiology tape or Strapping tape is usually associated with sports, giving support to athletes and apparently, a physical edge, (without there being any scientific data to show that it has an impact on performance or prevents injuries), the 'kinesio tape' was popularised and became a style statement during the 2012 London Olympic games (see figure 11.)

Figure 24. section 2.4.1.) use of a bandage to make the foot look sick, which makes a critical commentary on the torturous aspects of long term high-heeled shoe wear along with fetishising the high-heeled shoe as object. I took this concept in a different direction, reflecting critically on Scott's original work, but adding a twist, through combining opposing elements such as the kinesio tape and circuit. I did this to compose a new visual meaning, that supported the idea of 'demaking' the high-heeled shoe and which proposed a poetic 'suspension of disbelief'[145].

This approach of playing with the foot and human-made elements facilitated clash of styles and symbology akin to the ideas of Sofer (2003) and Elam (1980). Combining these opposing materials in a design led to a humorous, strange outcome and a tool of expression.

Figure 64. Playful physicalizing experiments with foot, 3D-printed heel, circuit and kinesiology tape, 2015.

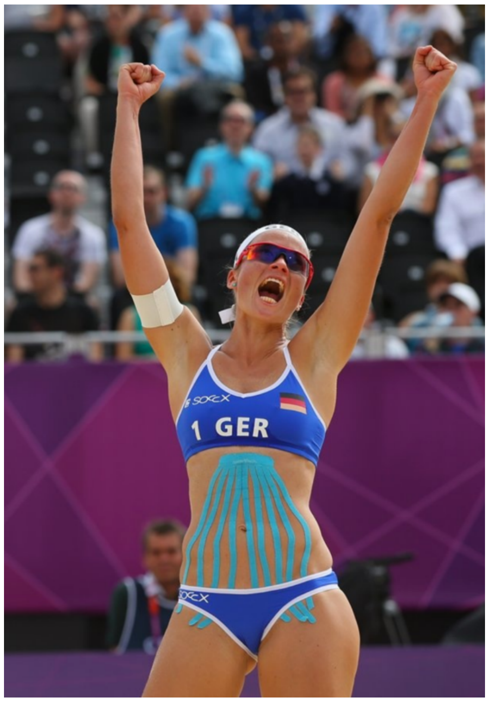

Figure 65. Beach volleyball player Katrin Holtwick adorned with kinesio tape.

[145] See Appendix E: Definition of Terms.

Analysis of Practice

- The interconnectedness of cross-disciplinary fields expressed in the background literature lead to text to visual sampling to inform a new shoe design:
    - The shoe stretches beyond broader visual culture as represented in sport, scientific invention, fashion and further afield.
    - Prop acts as symbols and tools of expression.

4.4.2.5 Playing the heel

The in vivo process began by figuring out the types of foot and/or shoe sensing and actuation features and requirements. For example, pressure sensors attached under big toes could provide switches to change pre-sets in a Max/MSP patch in a timeline of sound events. Working together with my engineer and technologist colleague Sam, we did some basic gesture follower mappings when the feet were moving in synchronised repetitive movements, using data from the inertial sensors worn in the heels in real-time. A series of different phrases of foot movements was used, each sensor being linked to a movement very different to the next sensor and its movement, so the data would not bleed between the pitch, yaw and roll.

The following initial set of gesture to sound mappings (on earth and in air) was developed:

- Walking–long movement. A sound loop is time-stretched based on the speed of the gesture.
- Kick–depending whether kicking an object. The audio engine triggers with a fixed tempo the portion of the loaded sound.
- Shaking–multiple repeating movements of the foot.
- Jump–with 2 feet (up and down, probably only one axis) We carried out a data experiment with sensors taking 'acceleration' data from the accelerometer sensors during a series of jumps, separated and together, using 3 axes of output from the gyro.
- Pendulum – swaying of the foot back and forth.
- Dial foot- turning of the foot with the heel planted – based on the orientation of the heel, the audio engine selects the correlated sound wave.

Analysis of Practice

- Data collection from the heel sensors coupled with FM sound synthesis and gesture mapping creates a dual role for shoes:
    - Prop: symbols and tools of expressions.
    - Simultaneously visual and acoustically aesthetic, a new way of costuming the foot.
    - Interpreting foot speech through movement and sound in a costume, affords strange movements of the foot.

Reflections

Standing on one foot and swinging my leg, I could not get much range and it was hard to balance. Plus it required physical practice if I was going to incorporate aerial moves. The moving of the foot like a dial was also very limiting as to the range of the movement. All the movements felt restrained and, I didn't think anyone off-stage would see them if the feet were flat on the floor (due to stage height and fold back speakers). This could relegate the feet to be being hidden on stage, while the hands and rest of the body are seen performing.

If the foot and shoe heel is moving, then the leg is moving too. It'd be interesting to focus on using the foot in a different way, perhaps with consistent micro movements, where the focus is on an extra-normal moving and sounding foot that audiences can see.

The foot and toes can learn certain gestures. The foot in itself was very interesting, I could distinguish between curling of the toes and normal foot motion. Perhaps the big toe could be a switcher (by pressing the toe on the foot)? Though the foot was interesting via actuating its natural movements, I didn't have enough sensors to work directly with the feet and this would be something I could pursue later in the research.

The initial set of gestures were mapped to polyphonic tones in FM Synthesis, which enabled me to compose in a very experimental way as we just had the x and y axis (very rough gestures). However, this missed many of the finer personal foot gestures. I was aiming to have greater range of motions of the foot in the air and on the ground as inputs including the movement of the foot rolling from one side to the other (eversion/aversion), the full acceleration of the foot and leg, flexion and extension, abduction and adduction, elevation and depression, as well as motions that are used in sports science departments for example. Overall, there were many more expressive movements I wanted to experiment with.

The first steps with gesture to sound mappings led me to do an analysis of how the foot moves through space and to study the way the foot operates alone, how it moves in the shoe and how the shoe moves. I also needed to design a series of meaningful gestures (taxonomy of gestures) which would be connected to different sounds. To do this, using my artistic method approach of cross-disciplinary creation, I sought to explore other fields of movement research to find ways I could interconnect other knowledge with my own.

I also referred to the literature and Bataille's critique of the 'Big Toe' (described in section 2.3.1.) where by the big toes and feet are described as 'base idiocy' and 'feet in the mud' performing such menial tasks such as a 'back and forth movement'. In support of Eschun, also discussed in section 2.3.1, I wanted to suspend such ideas. My artistic intention was to contradict Darwin's 'division of labour' and the perception of feet being an infrastructural support for the hands to perform. I did this by inverting the feet, suspending them and reversing their role, by turning things upside down and performing the shoes in aerial mode instead of in a gravity on-the-ground position. To do reflect these deeper ideas with my shoe instrument and set of movements, I decided to study human foot movement, which led me to a university sports science department which I will unpack in the next section.

4.4.2.6 Foot Kinematics: Taxonomy of gestures

As part of this research project, I took up an artist-in-residence at Pennsylvania State University (Penn State) for four months. During this residency, I had the opportunity to conduct research at multiple specialist schools of the university including the College of Health and Human development, Muscle Function + Locomotion Lab, Biomechanics Laboratory, Arts & Design Research Incubator (ADRI) and the College of Arts and Architecture. My collaborators were sports scientist, Dr. Jonas Rubenson (Associate Professor of Kinesiology and Physiology) and Prof. Andrew Belser (Professor of Movement, Voice & Acting, School of Theatre and director of ADRI).

Led by my personal artistic method, unexpected side projects (like the visualisation projects and lens based works I describe in this section) fostered 'reflective practice' (Schön 1983) discussed in Chapter 3 as well as unexpected connections and new inputs.

My initial aim at Penn State was to immerse myself in the practice of sports science motion exercises of the foot in a motion capture lab, in order to see how this could inform the taxonomy of gestures for my shoes and the artistic opportunities of the feet (artistic foot expression) evolving from these experiments. I began by carrying out a series of basic motion exercises on a stool, legs and feet in the air (I called this *free-style chair*), wearing the high-heeled duct taped shoes (see Figure 67.) with reflective calibrated markers attached to key points on the shoes, heels and shin (tibia) pads (see Figure. 66).

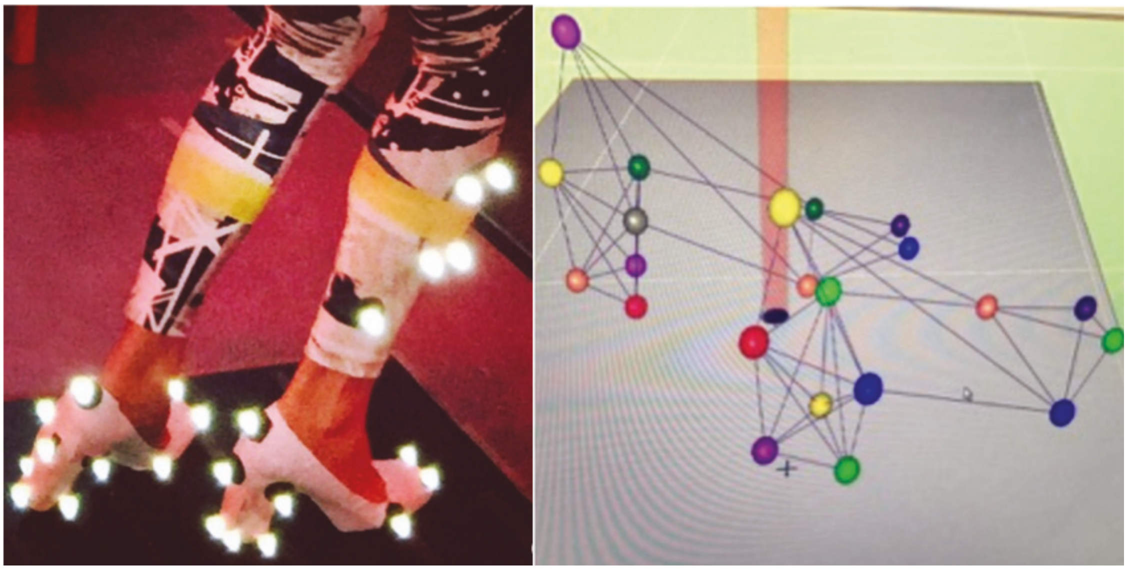

Figure 66. Infrared points attached to key points of *CEF P1* high-heeled shoes and shins to analyse movement in 3D motion data acquisition for the Biomechanical Analysis of 3D motion capture data.

I wore an upper body costume resembling high-vis workwear (symbolising 'artist at work', a mental concept I chose to embody as I performed the experiments). Secondly a series of separate experiments were carried out with bare feet inside the 3d motion capture arena on the force plates (see Figure 68. and Figure 69.). Below is a list of infrared (IR) points attached to key points of *CEF P1* high-heeled shoes and shins to analyse movement. See also Figure 66. above.

- Left tibia: 4
- Right tibia: 4
- Left ankle: 1
- Right ankle: 1
- Left high-heeled shoe: 5
- Right high-heeled shoe: 5
- Left heel: 6
- Right heel: 6

Following the initial *free-style chair* experiments with the high-heeled shoes, I performed standard sports science kinematic exercises of the foot with spherical infrared markers. These markers were precisely placed and calibrated for retro-reflective motion capture of the foot and tibia. See Figure 69. for the colour coded corresponding foot and tibia markers.

In these experiments, we measured the human foot kinematics using the following taxonomy of gestures[146]:

- Inversion/Aversion
- Abduction/Adduction
- Dorsiflexion/Plantar Flexion
- Eversion/Supination.

[146] See classification of foot gestures: https://www.resna.org/sites/default/files/conference/2015/wheeled_mobility/student_scientific/lyons.html

Figure 67. Performing *freestyle-chair* foot motions with reflective markers on high-heeled shoes and shins, using motion capture system for real-time data analysis of movements and infrared cameras. Biomechanics Lab, Pennsylvania State University, 10 April 2015.

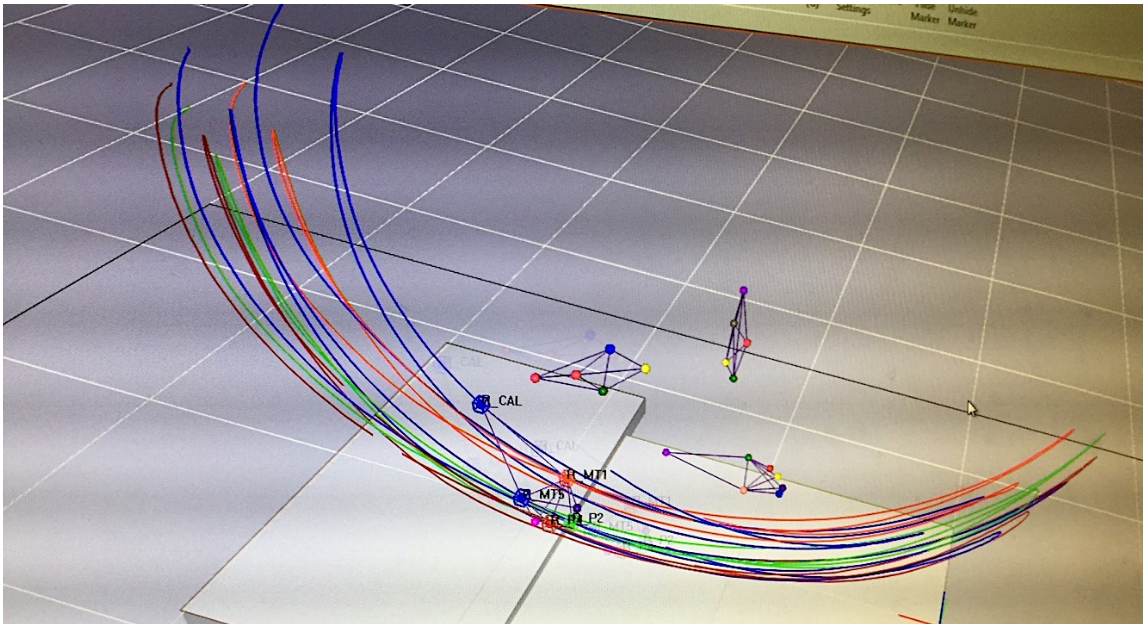

Figure 68. Performing kicking right foot backwards and forwards with reflective markers on feet and shins, using motion capture system for real-time data analysis of foot movements and infrared cameras. Biomechanics Lab, Pennsylvania State University, 10 April 2015.

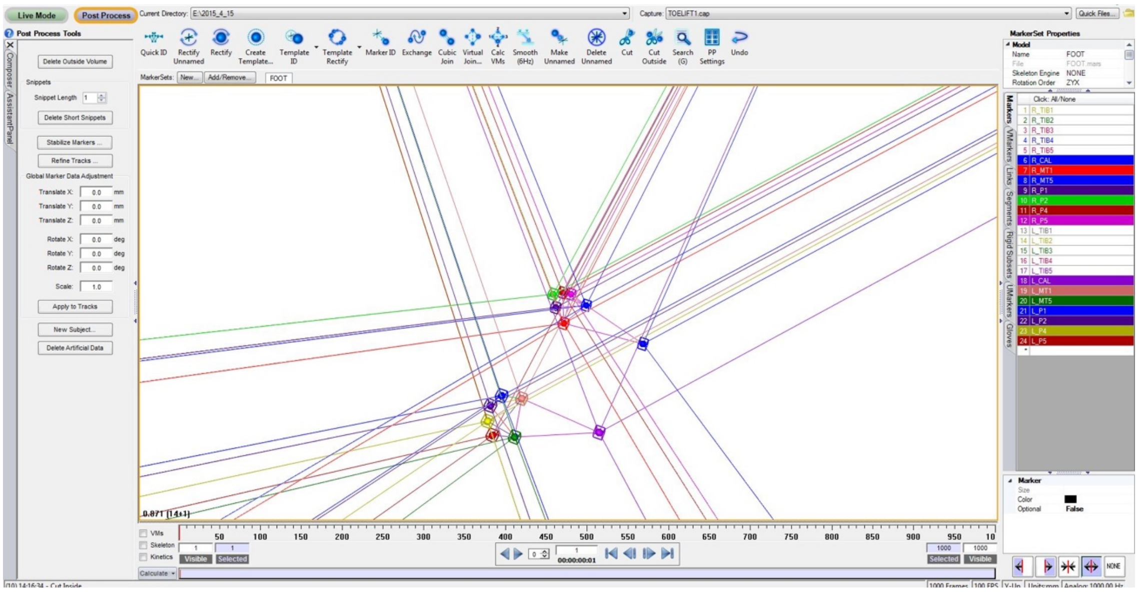

Figure 69. View of *Cortex* program showing colour coded left and right foot markers. The lines represent the trajectory from each marker to the camera which I inverted in the settings as an artistic experiment for unexpected visual outcomes. Biomechanics Lab, Pennsylvania State University, 10 April 2015.

I experimented with the collected foot kinematic data to generate models in a program called *Coretex* (see Figure 69.). I then took the data and models and explored how I could use them to generate artistic works, as outlined in section 4.4.2.7. below.

In between undertaking experiments with Jonas in the kinesiology dept, I had insightful conversations with Prof. Andrew Belser and other artists working at ADRI, talking about the feet. Andrew trained in the Feldenkrais method, his research revolving around the feet and language and during one of our conversations he said, “release the feet, we tend to abuse the feet, treat them as surfaces, most people aren’t good with their feet” (2015, pers. comm., 6 June). The conversation was a turning point in my research, to start to think about the feet in a whole other way, as autonomous and able to have their own voice and perform other tasks rather than just balance the body like a support structure.

Whilst I was at the lab, I also investigated other available sensors that I could use directly with the actuation of the foot and toes, without a shoe. I tried out some toe pressure sensors (see Figure 70.) attached to the bottom of the foot connected to a portable data acquisition system. I was less interested in these though as they required the foot to be in a gravity and I was more interested in anti-gravity work and exploring the feet in different contexts.

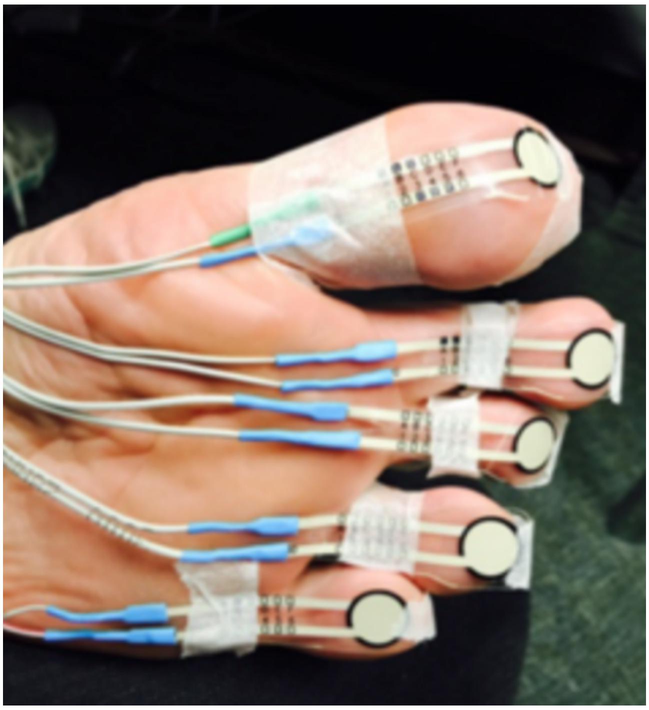

Figure 70. Wired pressure sensors (attached to portable data acquisition system) on the sole of the foot to measure contact of the toes with the ground.

4.4.2.7 Artistic opportunities made by the feet

During the experiments at Penn State, I explored the *Coretex* program as an artist and not as a sports scientist. I pushed the settings of some of the parameters of the kinematic foot models in the software to inform artistic 'errors' which would create interesting unusual visual effects (see Figure 71. And Figure 72.). I also deliberately changed some of the data to produce exaggerated movements and visualisations that were less accurate but more artistic.

I decided to film the kinematic foot model visualisations directly from the screen with a video camera and adjust the visualisation footage in Final Cut Pro to enhance the imagery colour and style. This approach created a messy rather than slick animated representation of data which also created an aesthetic humour.

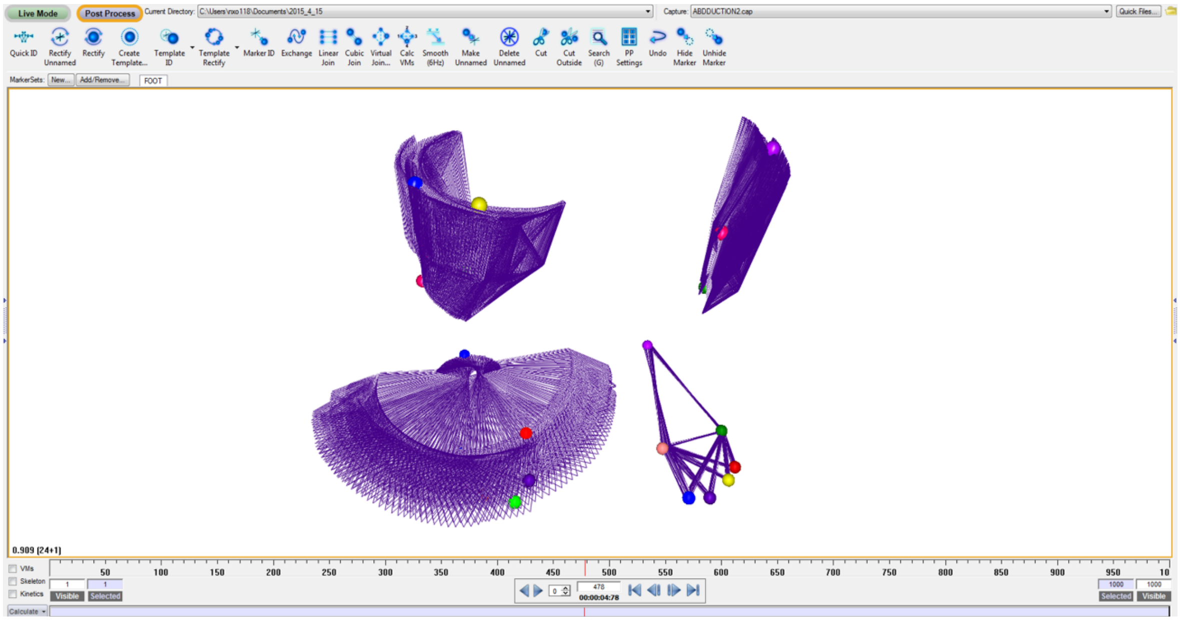

Figure 71. Artistic processes made by the feet. Creative interpretations of an abduction kinematic model in motion with a 'echo' (delay of movement) assigned to each point. This image is from front on, the heel of the foot staying in one position and the front of the foot going from left to right, the two shapes above are the points on the shin pads, which are used in all sports science 3D motion experiments in the lab, so as to have a correct calibration (for me these became additional decorative elements in space).

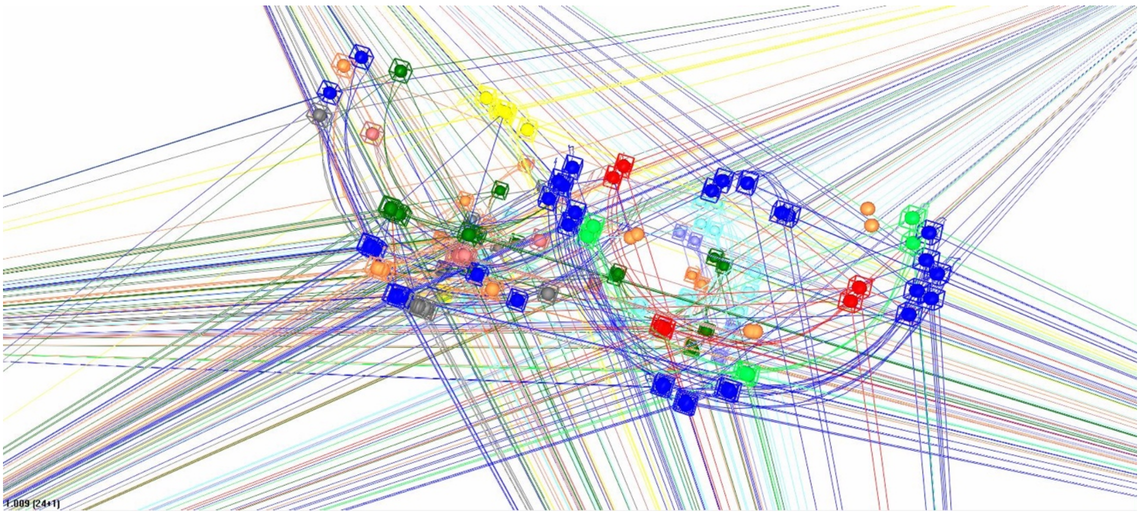

Figure 72. Artistic interpretations of an *abduction* kinematic model in motion, looking from above down onto the feet. The yellow markers symbolise the heel of the right foot. Both feet are performing the *adduction* motion.

I then went through the originally filmed experiments of me performing the taxonomy of gestures, taking the exact timings of where the data was extracted to build the foot kinematics and created video loops. Then I overlaid the pre-filmed data visualisations onto the original looped footage of me carrying out the taxonomy of gesture experiments. In this artistic process I was looking for different movements and forms of expression of the feet, ones that would be less about fine dexterity and repeatability (as with the hands) and more about unpredictable and un-repeatable acts of foot artistry or a new type of expressive language the feet or 'pedipulation' (Lavery 2012). See Figure 73. and vimeo video links below for examples of the data visualisations.

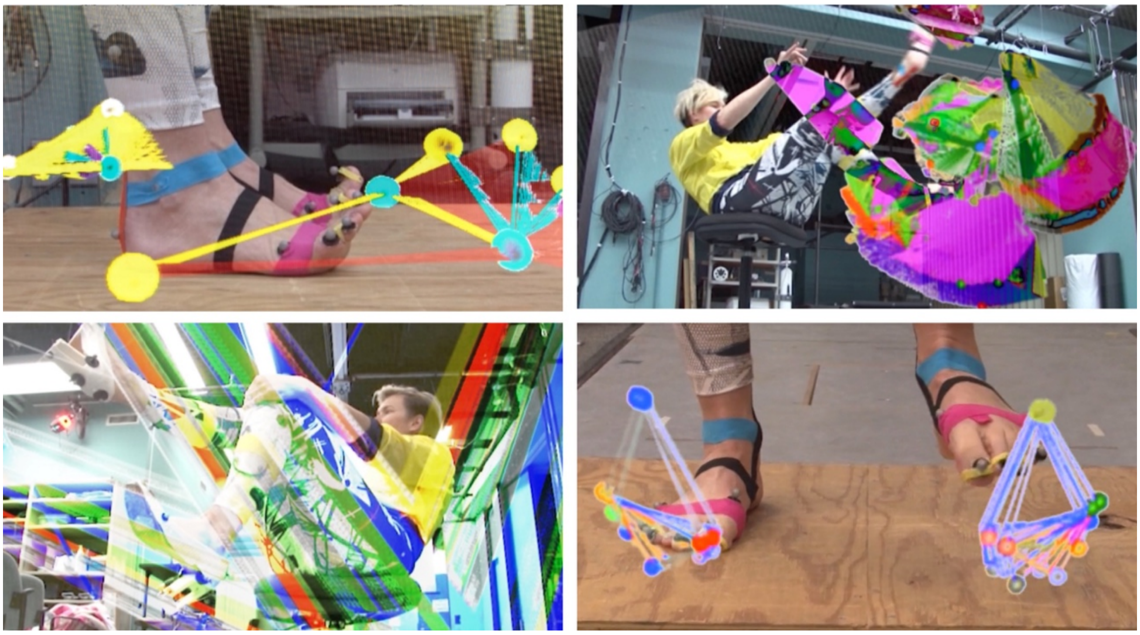

Figure 73. Video experimentations with foot data models.

Top left: Toe flexion/extension: https://vimeo.com/murrayleslie/taxonomy4.

Top right: *Chair Freestyle* 1 (barefoot): https://vimeo.com/murrayleslie/taxonomy7.

Bottom left: *Chair Freestyle* 4 (high-heels): https://vimeo.com/murrayleslie/taxonomy10.

Bottom right: Toe Wiggle (barefoot): https://vimeo.com/murrayleslie/taxonomy14.

Following on from the motion capture experiments, I contemplated other ways I could utilise the data and worked briefly with data sonification. I wanted to see all possibilities and thought it could be an interesting direction to take, by mapping the different kinematic foot points to FM sound synthesis. However, there were so many data points that it all became a bit noisy and time consuming and I realised this would be a whole research topic in itself and not the focus of this thesis.

Analysis of Practice

- Exploring processes in the biomechanics lab followed my personal artistic method which generated:
  - Unexpected opportunities led by the feet
  - A different type of artistic improvisation of the feet on the ground and in the air in a lab context
  - The designed object doesn't stop at the boundaries of its own material. Foot prototypes as audiovisual communication devices can guide artistic expression throughout a range of mediums:
    - Sonification
    - Visualisation
    - Lens based works for audiovisual theatrical performances [147].
  - Foot altering costume: shoes afforded me novel foot movement, creating a unique kinaesthetic experience.
- Six interconnected qualities are equally considered when costuming the foot:
  - i. Taxonomy of gestures
  - ii. Sound
  - iii. Physical aesthetics of prototype worn with a costume
  - iv. Affordances
  - v. Agency
  - vi. Philosophical concepts of literature.

Reflections

Even though these experiments with foot movement visualisation (and some very minimal experiments with sonification) are part of the work in my thesis, they are not the core focus. The process-based experiments exist as interconnected artistic opportunities (part of my personal artistic method) that came about whilst I was developing a taxonomy of foot gestures and artistic outcomes of using the feet in different ways. I use the artist

[147] Foot kinematic model visualisation and sonification videos. The videos went on to be integrated as scenografic [147] elements in Chicks on Speed performances; Pohoda Festival, 09/07/2016, Pohoda Festival, Trenčín, Slovakia (see figure 22.), Chicks on Speed performing *The Art of Work*, NTU Centre for Contemporary Art, Singapore, 2017 (see Figure 30. and associated video documentation) Venice Biennale live performance of *CEF P1* (see video documentation: https://www.facebook.com/alexmurrayleslie/videos/10153278795022154/), *FOOTwerk* (see Figure 30.) and during a jam session at Centre Pompidou (see video link: https://vimeo.com/149429831).

residencies (ArtScience collaborations) as ways to help me to develop new work (unknown outcomes) with the shoes which are informed by these unique experiences and the people I work with at these places.

With my new understandings of a taxonomy of gestures of the foot, it was time to go back to the workshop and develop a gesture to sound mapping system.

4.4.2.8 Sounding the Heel: Gesture≈sound mapping-System 1, Version 1

Working from some of the taxonomy of gestures developed in the sports science lab at Penn State, working with Sam I selected the below motion sets (on the ground and in the air) to create gesture to sound mappings using polyphonic sounds in FM synthesis in Max/MSP:

a) Dorsiflexion
b) Plantar Flexion

a) Inversion
b) Eversion

a) Kick forward
b) Kick backward

a) Foot angle right
b) Foot angle left

The filter parameters could be altered in real time including LFO, pitch, delay and distortion. I selected these motion sets because there was enough difference in the type of data that was coming in to create required changes in the pitch, yaw and roll.

The most challenging thing I found was getting used to playing an instrument with my feet while performing an instrument with my hands. I found it random and quite out of my control, but I liked this as I knew it would be a challenge to develop a new type of interaction with a foot based instrument.

I was not totally convinced about how I was moving with this new instrument, it did not come naturally or feel like it was working as a seamless extension of my feet. Everything required a great deal of effort.

Figure 74. Taxonomy of Gestures projected as scenographic elements during Chicks on Speed's live performance, Pohoda Festival, Trenčín, Slovakia, 09 July 2016.

Analysis of Practice

- There is a fundamental difference between hand-based and foot-based interaction with instruments that are exclusively made for the feet:
    - un-repeatable
    - non-virtuosic
    - intuitive
    - surprising
    - unpredictable
    - extra-normal (foot gestures create a new playing style of a new type of instrument)

        - nuanced motions / gross-motor skills
        - different methods of controlling an instrument
- The feet were used in unusual ways contra to every day actions of standing and walking. The foot instrument changes the balance of power in the body, where the feet usually act as an infrastructure for the hands to perform an instrument.

Reflections

At this stage in the process, the physical design aspects were not convincing. The heel did not look right and stood out at a strange angle when viewed from the side. The shoes had to look good, go with a costume and do something extremely ultra-normal if I was going to use them in COS performances. I also noticed the current system had restraining factors, it wouldn't necessarily allow me to perform differently each time (generating different sounds dynamically throughout one song). I wanted an instrument that wasn't necessarily going to be repeatable or transferable as with most musical instruments played by the hands.

Through experimenting with the shoe, Sam and I found the type of data that came from the shoe being played upside down (with the legs up in the air) had more peeks of definition and was more interesting when mapped to a range of notes and effects. This led me to decide to focus on the shoes in aerial mode.

4.4.2.9 Heel Repair

In 2015, I undertook an artist-in-residency in Singapore. I set out to collaborate with a local performer after refining the aesthetics and technical issues of the current *CEF P1* heels. I worked at ADM School of Art, Design and Media, Nanyang Technological University fabrication space to undertake the heel repairs. The original heel was rescanned (see Figure 75. left) and the top was reduced slightly (see Figure 75. right) to fit flush with the rest of the shoe. I also added a compartment for the Arduino and battery.

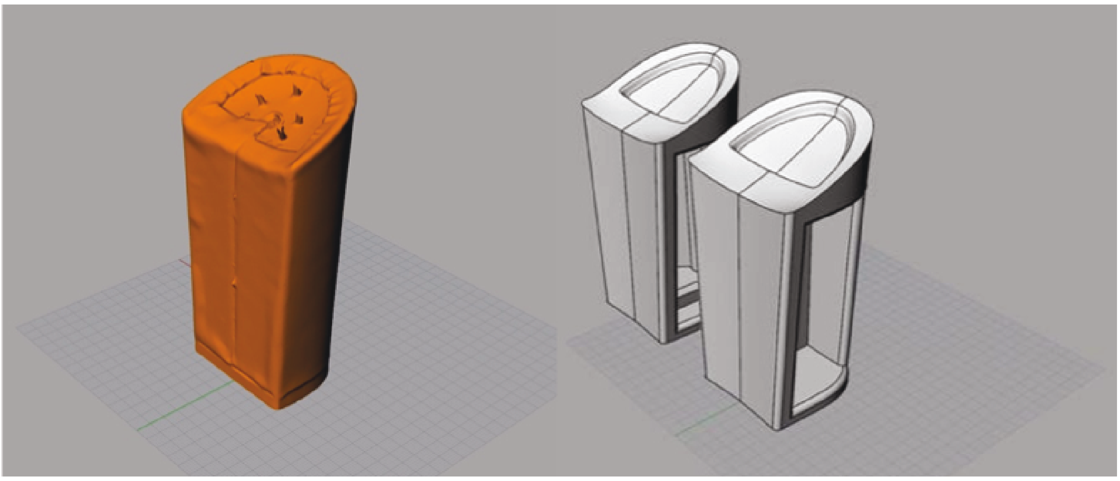

Figure 75. Left: 3D scan of original Bruno Magli heel. Right: 3D rendering based on 3D scan depicting, inner compartment for Arduino Fio circuit board and lithium battery.

On completion of the modified *CEF P1* heels I commenced a series of performance art experimental, audiovisual improvisational sessions[148]. Following these sessions, I was ready to take the shoes into a radically different direction and context. Through costume, sound and gesture I was going to communicate a socio-political message through the charged medium of pole dancing.

4.4.2.10 Pole dancing shoes

The experience of working on a taxonomy of gestures from a sports scientific perspective discussed in 4.4.2.7, successfully subverted what is usually done with one's feet in a sports science lab with such equipment and kinematic tests and produced several unexpected, interesting artistic outcomes led by the feet. Moving on, I decided to experiment with the revised heel within the charged frame of pole dance.

This came about through exposure to a community of artist pole dancers in Singapore. While still predominantly female, the pole dancing vocabulary has evolved. It is no longer just a feminine, erotic of sex industry thing like many people in Singapore

[148] Parts of the video art experiments went on to be edited into *CEF P1* in *FOOTwerk, Improvisations in Gender, Sound and Space* (short film) https://vimeo.com/murrayleslie/cefp1footwerk. Each of the following performance art projects can be viewed on Vimeo:

- *FOOTwerk, Improvisations in gender, sound and space*. Melissa and I together and solo on museum pedestals, https://vimeo.com/murrayleslie/cefp1footwerk.
- Alexandra and Lennat shoe jam NTU CCA. Drummer Lennat Mak and I, https://vimeo.com/murrayleslie/cefp1cca
- Mass Jam CCA. Melissa, myself, Singaporean performance artist Malvina Tan and drummer Lennat Mak, https://vimeo.com/murrayleslie/cefp1cca2.

and other places still believe it is. It is also currently popular in Singapore amongst artists (such as South East Asian performance artist pole-dancers Eisa Jocson or Daniel Kok), dancers, sports people and those wanting a good workout.

I went and tried it myself a couple of times, to understand the general 'pole fitness' complexity and strength required. As it requires at least two years of practice to do it in a convincing manner, I decided to find an expert collaborator with an understanding of performance art. I was introduced to trans pole dancer and performance artist Marla Bendini and we embarked on a series of workshops together to identify a new taxonomy of gestures for pole-dance wearing the *CEF P1*, with the aim of subverting traditional pole dance and challenging the stigma over pole dancing being related to stripper clubs (which remains with many pole-dancers still performing the old erotic pole moves).

Given pole dancing is evolving to incorporate other genres and techniques (such as Chinese pole dance), I wanted to build on this new pole language by adding sounding footwear and give 'voice' to the pole dancer (usually they are without a 'voice', dancing to pre-recorded music).

After some discussions with Marla (2015, pers. comm., 20th July), she made me aware of the importance of the pole dance shoe and laughed when I gave her the *CEF P1*, calling them "court shoes". Pole dancing shoes are platform shoes with a high heel, often referred to as 'stripper shoes', 'sexy platform heels', or 'lap dancing shoes'. These types of shoes elongate the leg of the dancer, give better grip when doing inversions and in some cases allow the dancer to do 'heel-clacks', also known as 'shoe claps' or 'heel bangs', which produce an acoustic sound. The higher the heel and plateau, the more impressive the sound and clear plastic plateaus give a crisper, sharper sound (Cleos Rock n' Pole 2017).

Marla and I took some classical pole dance moves and mixed these with our revised moves for the *CEF P1*.

Selection of classical pole dance moves[149]:

- Transition up the pole
- Heel Claps
- Kate Moss spin
- Chair
- Attitude Change
- Extended Frodo
- Brass monkey
- Bridged outside leg hang
- Chopper.

CEF P1 revised taxonomy of pole moves:

- King Arthur
- Flag
- Scaling
- Spider (see Figure. 76)
- Bonney
- Heel Lifts
- Grunge
- Connectivity
- Superman Meet hook
- Upside down lady man (see Figure. 76)
- Walking up walls (see Figure. 76)
- Ceiling dance (see Figure. 76)

We titled our collaboration together *Footwerk,* which is comparable to the work of Jocson's (2012) *Death of the Pole Dancer*, as both of our works set out to interrogate the way we witness pole dancing.

Audiences are surprised to find Marla, a trans pole dancer, making music with her high-heeled shoes, as this is an act of empowered creative production of the feet as opposed to overt sexualisation. The performance collaboration with Marla and the *CEF P1* seeks to renegotiate notions such as voyeurism and restrain, vulnerability and violence, sexuality and power through switching gender expectations and the meaning of a pair of high-heeled shoes in the act of pole. It is also a mediated act of 'deinscription'[150] of the original pole dance style.

[149] For a complete list of pole dance moves: http://poledancedictionary.com/moves/
[150] See Appendix E: Definition of Terms.

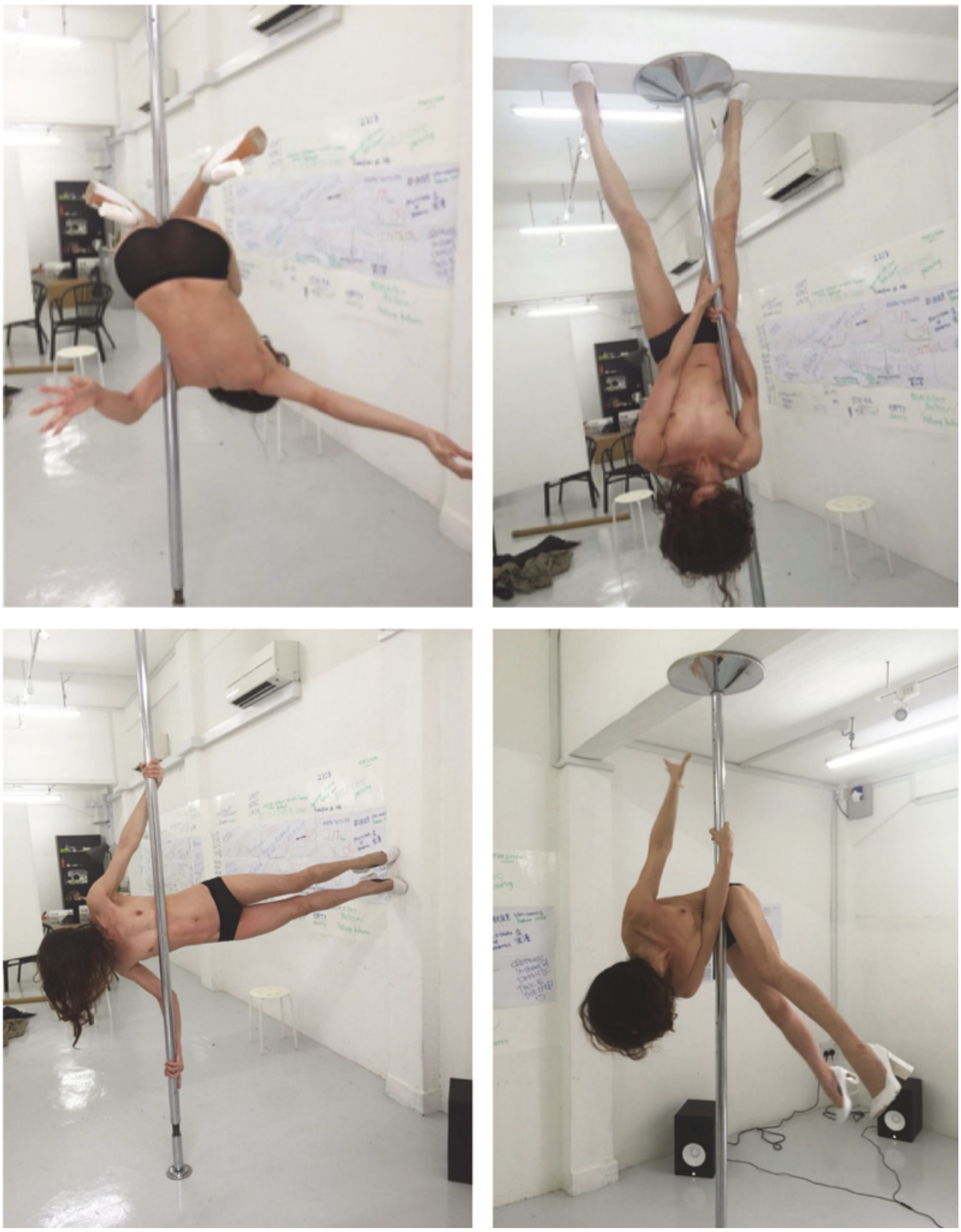

Figure 76. Marla Bendini testing revised taxonomy of pole gestures. Top left: *Spider*. Top right: *upside down lady-man*. Bottom left: *Walking up walls*. Bottom right: *pole transitions*. NTU Centre for Contemporary Art, Singapore, 22 July 2015.

The *Footwerk* performance collaboration was a series of improvised sessions in my studio over two weeks, where Marla performed the taxonomy of pole gestures and the *CEF P1* revised taxonomy of pole moves, mixed up, performed in different sequences. See mobile phone videos:

I reacted to her moves in real-time in the Max/MSP patch which Sam had recently revised to include pre-sets in the patch (version 3). I mainly improvised in a spontaneous way watching Marla closely to apply sonic mappings that the audience could identify with. For example, when Marla went up the pole, the pitch went up and when she spun on the pole I put on a distortion and delay filter.

Other elements that were interesting included when she gained momentum spinning around the pole, the sounds layered and became louder. This was something that was already built into system version 2 but did not work until now, as my playing gestures of my feet did not have a great range of momentum.

Shoe feedback

An expert[151] from the field of NIME, Lonce Wyse (2015, pers. comm., 30th July) reported to me on different ways of playing the shoes (after seeing the way Marla and I had played the shoes in the various video documentation). He suggested the shoes could be applied to different movement contexts, proposing two different styles of playing. Lonce also commented:

> "Feet are generally neglected as part of an interface, we didn't really think about them as functional and they're far away from our brains, for whatever reason, they have a different role in expressing ourselves than our hands do for example, but it's not just less, it's different and there are some really interesting things there to explore".

In other external correspondence;[152] discussions centred on the sounding shoe informing a different type of movement with the feet in pole dancing.

[151] Associate Professor Lonce Wyse, Department of Communications and New Media, National University of Singapore http://lonce.org/

[152] Private correspondence with observers in Singapore; Daniel Kok (performance artist and international pole dance champion), Russell Storer (senior curator, National Gallery of Singapore) and Eugene Tan aka Becca D'Bus (Performance Artist). For further information on their practice: Daniel Kok visit: http://www.diskodanny.com/ Becca D'Bus: http://www.riotdragshow.com/

Analysis of Practice

- Different activities constrain the kinds of gestures that are made. The discipline is a way of thinking about limitations that also provide a different kind of freedom.
- Semantics of a trans person doing pole wearing *CEF*:
    - The sound works with the meaning of what's going on in the performance, it changes the original meaning of pole dancing as being sexy and voyeuristic.
    - Performance Art.
- CEF shoes affords a different kind of movement of the feet in Pole dancing:
    - New Taxonomy of gestures for pole dancing.
- Shoes are connected with intimate personal identity:
    - like a NUI and *Computer Enhanced Footwear* designed around a specific player's needs.
    - repertoire of gestures controlling personal collection of sounds, intimately tied to sound synthesis algorithms.
- The feet express themselves differently to the hands.
- Role of Hands and Feet was exchanged: the hands supported the feet to carry out expressive musical gestures.
- *CEF* pole dance as performance art and from of mediation:
    - The shoes are a way for a person to communicate (mediate a person).
    - Create a dialogue with the social, the political and gender issues and take the music and sound into a new realm.
    - It becomes less about abstract sonic gesture and more connected with socio-political meanings or confronting the audience with ideas.
    - Decontextualized shoes as being purely musical instruments, they become music communications, not just synthesis or just interaction, but real time communications though sound and through gestures.

Reflections

The collaboration with Marla described in this section localised an exploration of sound, semantics and semiotics with the shoes and their gestures in the space of 'pole dancing performance art' to communicate deeper social political ideas.

Conversations with Lonce helped me see that I was getting into performance art that was beyond sound art or creating music—a kind of dialogue with social, political or gender issues, which takes the music and sound into a new realm. So the work started to become less about abstract sonic gesture and more connected with exploring and communicating greater issues.

This connects well to ideas discussed in section 2.5.1 where shoe semiotics have been used to facilitate an epiphany or empower the wearer to do things they usually wouldn't do. *CEF P1* had transformative powers. Like Bowies' red shoes in the video *Lets Dance*, *CEF P1* also delivered a similar simple and direct political statement. The shoes empowered Marla "to negotiate meaning and position" (Gleeson and Frith, cited in Dilley et al. 2014, p. 1).

Having successfully found a way for the shoes to be protagonists to build up a deeper meaning through the medium of pole dance (gestures and sounds), I wanted to create a lens-based work based on a series of live improvised sessions of the shoes.

4.4.2.11 FOOTwerk: Improvisations in gender, sound and space

A series of public improvised sessions with Marla pole dancing the shoes took place in my studio at NTU Centre for Contemporary Art over a 12-hour period during Art Day Out. As part of this work, I produced a short film, *CEF P1* in *FOOTwerk, Improvisations in Gender, Sound and Space*, https://vimeo.com/murrayleslie/cefp1footwerk.

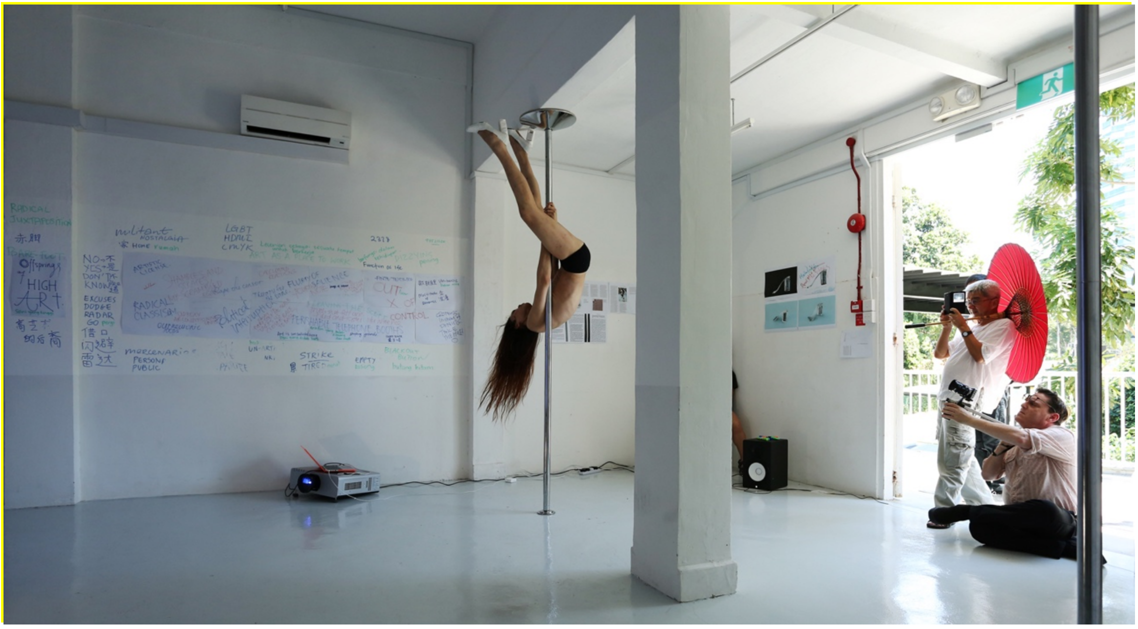

Figure 77. Marla Bendini performing *CEF P1 Ceiling Dance*, during Footwerk performance, *Art Day Out*, NTU Centre for Contemporary Art, Singapore, 25 July 2015.

For these sessions I continued to explore the space of pole dance and what sounds would best suit our newly developed pole taxonomy. I sat behind a lap top, changing filter parameters; pitch, distortion, LFO, harmonicity and length of notes on the system patch in real-time whilst Marla performed the shoes.

We found ourselves creating un-structured, non-repeatable dynamic improvisations for periods of around one minute (depending on how long Marla was connected to the spinning pole). I reacted to her movements in real-time by manipulating the Max/MSP.

The all ages audiences who attended seemed surprised and shocked to see a trans pole dancer performing in an art institute. The NTU CCA attached two big yellow signs on the door, warning audiences about what they would expect to see behind the doors of my studio. This was an act of self-censorship, which happens a lot Singapore in fear the Singapore censorship board flagging our performance and shutting down the CCA. But the performance with the shoes and Marla had a positive effect on the audiences—everybody wanted to see it. It was as though the locals were proud, agreeing that using the shoes together with Marla pole dancing was an art form and should move outside the sex clubs and into the streets and wider public cultural spaces.

Figure 78. *Art Day Out*, NTU Centre for Contemporary Art, Singapore, 25/07/2015.

Analysis of Practice

- *CEF P1* evoked a certain feeling in the viewer, an 'affect'.
- Experiences with the *CEF P1* led to greater importance being placed on the visual shoe to communicate the concept of *computer enhanced footwear* and its performance:
    - This shoe is not just an everyday high-heeled shoe. Marla called the *CEF P1;* 'court shoe' which has its own set of visual gendered associations, these coupled with digital means changed the gendered association.
    - A new type of shoe that affords new types of foot movements in contexts of pole dance and art performance.
    - Visual aspects of the shoe were becoming my key focus in the research trajectory.
    - The shoes informed the design aspects of the upper body costumes. Usually an outfit would be chosen and then the shoes, so this was reversed. Ideas can start with the costume.

- Comparing the art performance to pole dancing performance, different contexts afford different playing styles with the shoes; similarities included that the hands were supporting the rest of the body so that the feet could be in the air and doing something else than they would usually be doing. The hands became support structures for the feet to play a musical instrument.

Reflections

It was clear from Marla's suggestions that the 'court shoes' (2015, pers. comm., 25th July) *CEF P1* weren't perfect for pole dancing—the toes were covered, giving her less grip on the pole and they were too 'normal' looking like an everyday pump.

My new design thinking for a type of pole dance shoe was to create a deconstructed sole of a shoe with a heel for circuits and more foot and toes exposed (to grip the pole).

Overall much of this experience was about gaining confidence about improvisational performances with the *CEFP1*. In the next section, I describe my own personal style of performing the shoe instruments in different choreographed ways, with a different sound palette and costume characters.

4.4.2.12 Computer Enhanced Footwear live on Tour (performing with CEF P1)

The *CEF P1* workshopping sessions (with the new heel iterations) made me confident I had a workable wearable shoe system that I could perform with. COS rehearsals and concerts[153] now became a test bed to experiment with playing the shoes.

In the following case studies, I was usually performing the shoes solo or in tandem with COS co-founder, Melissa Logan. Choreographer Krõõt Juurak also performed the shoes with me at the controls of Max/MSP. The performances with the shoes were enacted (usually within a gesamtkunstwerk frame) using different upper body fashionable costumes, visual projections and scenographic elements to a specific song.

A key aspect about the following case studies was that I was always seeking to develop a new playing style or way of using the feet with the instrument and heels. Thus,

[153] For full list of public performances, events and media using *CEF*, See Appendix A: List of public events with Pre-prototype, *CEF P1*, *CEF P2* and *CEF P3*.

each live performance case study presents a unique theatrical playing style of the *Computer Enhanced Footwear Prototype 1*.

***The Art of Work* by Chicks on Speed, NTU Centre for Contemporary Art, Singapore 29/05/2015**, https://vimeo.com/murrayleslie/cefp3chicksonspeedtheartofwork

For *The art of Work*, we entered the stage with the shoes emitting subtle sounds as we put them on live. This created a dramaturgic build up, which was followed by a shoe drumming improv for two minutes. Melissa and I performed the shoes in tandem using mirrored choreography poised on white museum pedestals.

Our choreography was inspired by the work of Hilde Holger and Mary Wigman, pioneers of 'ausdruckstanz', a choreography scene in Germany informed by forms of embodied knowledge, phenomenological thinking such as Husserl's notion of 'kinaesthetic consciousness' (as discussed in the methods section 3.2.1). We borrowed Holger's concept of performing exercise routines onto the stage, interpreting them in a humorous way by building on a sports exercise called *obliques*. See Figure 79. and Figure 80. below.

Our process also interestingly harked back to something Melissa spoke about during our COS touring. Given we were travelling so much, she suggested to keep fit, we should just do our sport on stage. Hence our choreography and the cycling gesture represented this cross disciplinary thinking.

The performance also incorporated some of the foot kinematic data visualisations from my experiments at Penn State University. We also mimicked some of the taxonomy of gestures in the performance with the shoes, re-contextualising them as an act of on-the-spot experimentation and reflexive practice.

Figure 79. Chicks on Speed performing *Cycling* playing style during the scene *FOOTwerk* live, NTU, Centre for Contemporary Art, Singapore, 29 May 2015.

Figure 80. Inspiration for choreography. Expressionist dance and 'Ausdruckstanz' pioneer Mary Wigman and Hilde Holger (work pictured), London, 1950's [154].

[154] For more information on expressionist dancer Hilde Holger http://hildeholger.com/

Footwerk CEF P1 prototypes, Chicks on Speed live at Venice Biennale, 7 May 2015

https://www.facebook.com/alexmurrayleslie/videos/10153278795022154/

Standing on a white museum pedestal, balancing on one foot (out of shoe), Krõõt performed with the shoes. She had one shoe on her aerial-positioned foot for sound actuation, and one in her hand also for actuation, swinging hand and foot around in windmill-like playing style. She performed with us for five minutes, within a jam session featuring drums, keyboard, saxophone and spoken word vocals. During Krõõt's choreography, I reacted in real-time to her movements, changing the audio effects and length of note in the Max/MSP patch.

The difference between this performance and others, was that Krõõt interpreted the typical guitar *windmill* gesture with her hand, whereas, Melissa and I had been doing this with our feet. It was the first time this switch happened. Also, Krõõt's choreography with the *CEF P1* was more focussed on movement, rather than playing gestures to create sound. This is because dancers do not tend to focus much on the sound they are making, and generally do not having experience with this style of performance and using musical instruments (2017, pers. comm., 36 October).

Overall, Krõõt's style of performing the shoes during the Venice Biennale, switched roles of the feet and hands, as a way of creating a 'defamiliarisation' of what the feet usually do.

Donauinselfest, Vienna 26 June 2015

For this performance in Vienna, COS performed with choreographer Krõõt Juurak, acoustic drummer Mathias Brendel and visualist Tina Frank. The *CEF P1* was performed by Melissa and I in tandem on road cases—an 'rock style' interpretation of the white museum pedestals used in other performances. We performed the movements in a similar sporty style to the NTU CCA performance, but this time with a drummer improvising for three minutes, reacting in real time to our choreographed sounding movements.

Figure 81. Performing *CEF P1* improvising with Melissa Logan and drummer Mathias Brendel, Donauinselfest, Vienna, 26 June 2015.

Figure 82. Performing *High Heeled Shoe Guitar* and *CEF P1* during the song *We Don't Play Guitars*, Donauinselfest, Vienna, 26 June 2015.

The improv with *CEF P1* moved seamlessly into playing in tandem with *High Heeled Shoe Guitar* (*HHSG*) to the song *We Don't Play Guitars*. I performed *CEF P1* balancing on a pedestal like road case with my kicking legs as if doing a leg solo (see Figure. 81) and also mimicked a guitar solo by playing the *HHSG* with my hands (see Figure 82.).

Shoe instruments can strengthen the anthem-like meaning and expression of song lyrics. Playing *HHSG* and *CEF P1* in tandem with windmill style movements, convincingly evokes and challenges the typical 'male guitar solo' style of performing. In addition, the sounds of the analogue *HHSG* played together with the digital *CEF P1* provides an added interesting juxtaposition. This resonates with the meaning of the song *We Don't Play Guitars* which challenges the playing of classical musical instruments by using guitar samples.

The different sounds of *HHSG* and *CEF P1*, also expressed the 'battle' between analogue and digital instruments and a need for new musical instruments. As Busoni (1907 as seen in Patterson 2016) indicates, classical musical instruments can restrict the development of music. New forms of music require new instruments (Redfield 1935), to create new, unheard sounds and express new thought expressions (Varèse & Hirbour 1983).

This concept of expressing musical emotion through new musical instruments is also complemented by other elements of the performance such the clothing worn by the performer and the way they move. These aspects are interconnected and for my work I consider considered them as a whole to generate musical emotion and make performative expressions and statements on stage.

Pohoda Festival, Trenčín, Slovakia 9 July 2016

https://www.youtube.com/watch?v=sZlUDKUHpvc

While performing *CEF P1* to the song *We don't play guitars*, I spontaneously developed a performance move which I call *head over heels* (see Figure 83.). This choreography is my artistic response to philosophical concepts expressed in literature (see section 2.3). It challenges Darwin's philosophy about 'the separation of the body' and Bataille's artistic concept of the feet being stuck in the mud and the hands being closer to the heavens.

Figure 83. Performing *CEF P1 head over heels* solo during the song, *We don't Play Guitars* Pohoda Festival, Trenčín, Slovakia, 9 July 2016.

Head over heels choreography set out to keep the hands busy by using them as a support infrastructure to balance the rest of the body in an inverted position, so the feet could perform. By turning my body upside down, I achieved Eschun's aim (expressed in section 2.3.1) of freeing the feet from the colonising body.

Performing in this inverted playing style 'defamiliarises' a rock solo, which is usually performed standing on two feet with the hands in control of the instrument. Also, using the feet in a new, unexpected, liberated and un-predictable way turns our thinking upside down about the way we should play instruments. To perform with the feet and shoes you have to un-think and unlearning traditional musical practices to discover new ways of playing and connecting with the body.

While head over heels looked good, the playing style also brought challenges. To play this style, I rested my weight on an amplifier while I had one hand planted on the stage for support, the other hand playing *HHSG* and my legs in the air playing *CEF P1*. It was difficult to get off the amp, so I ended up having to get help to get down. Interestingly, somehow this 'effort' of performing the instruments played a role in strengthening the scene. Perhaps because 'effort' is usually afforded by a classical musical instrument.

Another limitation of this choreography is that I cannot get a wide range of movements and sounds from the shoes. I can only kick my legs back and forth (due to the amp and me having to balance). However, this was not a major issue as head over heels is more about exploring the visual effects of the body being inverted and directing the gaze towards the shoe instruments to create an unexpected, bizarre and engaging body sculpture guitar solo.

Volksbuhne, Berlin 31 October 2016

https://vimeo.com/murrayleslie/cefp1chicksonspeedvolksbuhne

Adding on to the *head over heels* playing style explored at Pohoda Festival, at Volksbuhne I experimented with dragging the *HHSG* along the ground and on the front of amp's grill cloth. Playing with nuances of the feedback, it was at times like a performing a Theremin to get the different frequencies from the amp (see Figure 84.).

I also explored full body aerial modes of playing *CEF P1* (see Figure 85.) during a three minute improvisational session, accompanied by trombone, keyboard, acoustic drums and violin. Performing the shoes in aerial mode was similar to pole dancing, but the hands are also free to move. This performance style also created an endless choreographed sound stream due to constant accelerated motions of the feet and legs.

Figure 84. Performing *Head over Heels* with *CEF P1* and *High Heeled Shoe Guitar* in hand, dragging it along the grill cloth of the amp and along the floor to generate feedback and interesting effects. Chicks on Speed live, Volksbuhne, Berlin, 31 October 2016.

Performing in aerial mode was not like anything I had tried before with the shoes and I actually found it to be quite enjoyable. I really noticed the larger range and unusual things you can do with your legs when they are not having to act as support structures for the rest of the body. It is also less strenuous to perform the shoes in this way. You do not have to rely on balancing other parts of your body and are free to just perform the feet and legs.

This playing style afforded a theatrical epiphany during the performance—wearing magic shoes can make you fly. Out of all the performances, this was the most surprising way to perform the shoes and audiences were shocked to see me suddenly flying above their heads. Performing in aerial mode drew the audiences gaze towards the feet and shoes. It was super hero like, but instead of magic boots, magic high-heeled shoes created this epiphany. This is similar to the themes of shoes creating an altered state of freedom or escapism (discussed in sections 2.5.1. and 2.7.3), such as where Dorothy is transported to a better place in *The Wizard of Oz*, or the *Eudaemonic shoes* facilitate 'magic' by winning against the roulette wheel. The *CEF P1* shoes, like other shoes in fairy tales, facilitated some kind of transformation or magical transportation, when performed in flying aerial compositions.

Figure 85. Sound checking the shoes in aerial mode, expressing the concept of epiphany one has when wearing magic shoes which can make you fly, Volksbuhne, Berlin, 31 October 2016.

Isle of Wight Festival, UK 14 June 2015

Our COS performance at the Isle of Wright Festival (IOW) was the first time Krõõt performed the shoes in *the swim* mode (see Figure 86.). With her body lying across a road case, she swam with her limbs in the air.

Overall, the large swimming gestures worked well on a bigger stage and the road case acted as a pedestal, which enabled a better audience view of the weird shoe performance. The performance also gained the attention of a Guardian reporter[155] who writes:

> In the Big Top things get even weirder…. Chicks on Speed feature a fluffy space yeti trying to get a tune out of a miked-up stiletto. Slowly, IOW is growing an edge" (Beaumont 2015).

Figure 86. *CEF P1 the swim* choreography performed by Krõõt Juurak, Chicks on Speed performance, Isle of Wight Festival, UK, 14 June 2015.

[155] See Appendix A: Public Events for a list of all media.

Salo Club performance art collaboration with ORLAN and Anat Ben-David, Silencio, Paris, FR 20-22 February 2017

At a performance at Salo Club in Paris, I performed *CEF P1* and *HHSG* during the cong 'Memetic Octopus' by lying over an amp, and moving like I was running on air. This movement which I term *levitating-running on air*, when performed together with the neon glowing costumes, make-up and props, created a magical illusion effect on stage.

During the performance, my horizontal body performed in tandem with my collaborators Anat and ORLAN. Using an orange scarf as a prop we formed a collective body-sculpture[156] (see Figure 87.).

This choreography was a direct reaction and my personal version of the swim movement Krõõt performed at Isle of Wight. The playing of the shoes was unpredictable and a reflexive action, an improvised on-the spot experiment, using the knowing of the previous performances.

Figure 87. Performing *HHSG* and *CEF P1* with *Levitating-running on air* playing gesture with ORLAN and Anat ben David, Salo Club, Silencio, Paris, 22 February 2017. Photo by Louise Greggory.

[156] Body Sculpture is a choreography we developed early on in COS, as described in the artists background section 2.2.

Diane Pernet and Centre Pompidou present Chicks on Speed in collaboration with Hans Boodt Mannequins and Manish Aurora, Centre Pompidou, Paris 9 December 2015 [157]

https://vimeo.com/149429831

During the COS performance at the Centre Pompidou, the *CEF P1* facilitated a different type of improvisation on stage. Melissa, myself and Ari Benjamin Meyers composed an instrumental song titled *Egypt*, which featured *CEF P1*, keyboards, drums and saxophone. Each instrument was layered over a constant heavy drum beat of 80 bpm.

I decided to perform the shoes intermittently, when there were oscillations of the pitch from Ari's keyboard, during the chorus-like parts and at other intervals when it was least expected. It was almost like playing out of sync with the other instruments, performing a solo instrument 'on top' of the mix.

To start, I performed with one shoe in hand, moving from the back of the stage to the front, physically pushing the sounds forward towards the audience. Then later in the piece, I used the shoes on the feet, in an inverted shoulder-stand position taken from the yogic practice of inversions in Hatha yoga (see Figure 88.). Performing *CEF P1* with both the hands and feet references ideas expressed by Martin Heidegger (see section 3.2.1) who proposed the concept of objects being experienced in different ways. Switching the *CEF P1* from the hands to the feet presented the high-heeled shoe object as a seamless extension of the foot, thereby metaphorically proposing 'knowledge at foot' instead of 'knowledge at hand'.

Overall this process of using *CEF P1* in multiple ways during the performance, subverted the way high-heeled shoes were represented, which helps the audience to make new associations with objects.

[157] Refer to 2:02 mins for performance with *CEF P1*.

Figure 88. Performing *CEF P1* in inverted shoulder stand position inspired by Inversion informed by yoga practice.

Look Therapy-All Over Over All **fashion performance, Kunsthalle Basel, Switzerland 14 May 2017**

https://www.facebook.com/alexmurrayleslie/videos/10155273149967154/

During *Look Therapy-All Over Over All*, *CEF P1* were performed as part of a fashion performance during the day time. Performers and musicians stared for long periods of time at each other while wearing 'looks' or garments created for the performance. The active looking transmitted a positive gaze of admiration and focus from the audience to the garments and accessories (shoes, handbags and hats) in this case 'look therapy'. The intensity of concentrated, exaggerated looking was also adopted by audience members, who would stare at fashion and costume details (including my shoes) for long periods of time. Also, as the work was presented in the round, the audience could experience my playing from different angles, up close and personal. This kept a nice intimate tension and focus on my playing of the shoes.

I performed *CEF P1* with a decorative musical plant device[159] and wore a bespoke fashionable costume made by students[160]. One leg was exposed and the other was covered with a faux fur. Redesigned second-hand clothing was used for the costume, which juxtaposed against the high-tech high-heeled shoes. I became a human representation of a costumed sculpture on a pedestal, a static life model.

In response to this, my movements began to look very sculptural, slow, exaggerated and accentuated and I spontaneously began to perform the shoes in a strange Jane Fonda lateral legs style (see Figure 89.). Other playing gestures included heel rotations, leg lifts, dipping the toe of the shoe inwards and outwards (performing *eversion* and *inversion* as experimented with in section 4.4.2.8) and slow kicking motions.

The minimal movements of *CEF P1* were contrasted with big sweeping modular synthesized sounds with full distortion, delay and maximum length of note from the Max/MSP patch. Performing in this context felt almost meditative. Everything felt slowed down compared to the usual pop performances I was used to, which are about keeping the audience engaged and constantly surprised, with fast and fun beats.

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[159] See http://www.musicoftheplants.com/en/
[160] See Appendix E: Project Acknowledgements.

Figure 89. Performing CEF P1 in *Jane Fonda lateral legs* style, Look Therapy- All Over Over All, Kunsthalle Basel, 14 May 2017

Working with *CEF P1* in various performance contexts for over three years, has revealed that the character and playing style of the shoes is adaptive. It changes according who is playing them and playing with them. Reflecting back on all of these experiences, I found *Look Therapy-All Over Over All* was the most successful use of the shoes in a performance with *CEF P1*. Unlike my previous experiences, this performance was clearly a 'fashion first' event. The audience was more sensitive and looking out for fashion doing peculiar things, instead of being more interested in dancing to music and watching a live show on stage (like at COS shows). Overall, I found this slower fashion style performance provided a more meaningful space for my instrument—all eyes and ears were on the shoes. As a result, this performance was the first time I had 5,000 views of one of my videos with the shoes on social media[164]. I felt I had reached the tacit moment (Polanyi 2009) and it was

[164] See Appendix A: List of Public Events with Pre-Prototypes (*Biped Shoes*), *CEF P1*, *CEF P2* and *CEF P3*.

time to move on to the next iteration of the prototype—the *CEF P2,* which I unpack in the next section.

4.4.3 Computer Enhanced Footwear Prototype 2 (CEF P2)

Figure 90. *CEF P2* 3D renderings.

4.4.3.1 The next IT dance shoe?

The experiences working with the *CEF P1* with Marla pole dancing led me to design a reduced, deconstructed shoe prototype (see Figure 90.) strongly referencing Margeila's *Paire de semelles de tabis* (see Figure 91.) yet cut off at the toes, to enable free movement of the toes.

CEF P2 is my own version of the power high heel reinterpreted into a musical instrument which also expresses socio-political concerns. Like with *CEF P1*, the aim for this prototype was to adopt the 'readymade' object spirit of dada, to find ways to appropriate the high-heeled shoe artefact and 'make it strange'.

I also designed *CEF P2* prototype to afford foot gestures more in tune with a pole dancer's needs, facilitating a liberation of the feet and toes in order to be able to flex the foot and curl the toes to grip the pole. Given this new iteration uses the same system as *CEF P1*, and because I did not fabricate my design, in the following section I concentrate on the performative acts and analysis of practice with this foot appendage[166].

Figure 91. ***Paire de semelles de tabis , cuir noir,*** 1996 by Martin Margiela.
Image courtesy of Musée de la Mode de la Ville de Paris.

4.4.3.2 Shoestravaganza

The following is a significant foot-based experiment case study that I conducted with *CEF P2*.

***Artstravaganza*, Chicks on Speed performance at *Modemethode*, Karl Lagerfeld exhibit, Bundeskunsthalle, Bonn, Germany, 12 September 2015**
https://vimeo.com/murrayleslie/footwerk-lagerfeld-bundeskunsthalle

Artstravaganza was a set of scenes celebrating the 'look of music' (as described by Melissa E. Logan during our initial brainstorming sessions) and the 'sound of fashion' based around COS songs. The aim for the show was to enact the shoes in a meaningful way within a chosen musical scene, while complementing the larger context of the event—a

[166] See Appendix F: Project Acknowledgements.

closing party for *Modemethode*,[167] the first comprehensive exhibition to explore the work of Karl Lagerfeld.

COS had worked with Lagerfeld on two cover photos for the release of *Fashion Rules!* single in 2001 (see Figure 92.) Therefore, it was unsurprising that some of the artistic aspects of working with Lagerfeld in 2001 bled into scenes of our performance *Artstravaganza* for his exhibition closing event.

Figure 92. Photo shoot for Chicks on Speed *Fashion Rules!* single. Photo by Karl Lagerfeld, 2002.

I devised the performance around our song *Fashion Rules! CEF P2* was performed by Krõõt Juurak, accompanied by a team of dancers, drummer, props and lightshow. In spirit of the event and Lagerfeld's cult Chanel catwalk shows, I built up the dramaturgy of the scene by integrating a catwalk show into the performance and constructing the shoes, live during the show.

[167] 'Modemethode' is the name of Karl Lagerfeld's fashion method, his ambitious, all-encompassing approach which includes not only the finished garment but the initial sketches as well as all the elements required for fashion shows, press material, advertising, catalogues and window displays. Every last little detail relating to his work is devised by Lagerfeld himself (Bundeskunsthalle 2015).

For the catwalk section, dancers strutted to the stage, walking in exaggerated 'catwalk style', some falling over now and then, some humorously pulling large suitcases on wheels. This drew the audience's gaze to observe the clothing and strange style of the dancer 'models'. Once they reached the stage, Krõõt and her bare feet were unveiled, poised on white museum pedestals.

Figure 93. *CEF P2* temporarily attached to the foot with a mix of tapes during COS *Artstravaganza* show at *Modemethode* exhibition by Karl Lagerfeld, Bundeskunsthalle Bonn, 9 September 2015.

All eyes were on her. There was a moment of silence and tension as she balanced on one leg, whilst I constructed the shoes live on stage. I used a variety of reflective and high visibility tapes, neon duct tape and kinesiology tapes to join *CEF P2* to Krõõt's, feet and ankles (see Figure 93.). The reflective 'high vis' tapes were similar to construction site workwear and brought the audience's attention to the feet in an almost dangerous "Watch out! Woman at work" style.

Posing around humorously in fashion model style, Krõõt then extended one leg, balancing on the pedestals and tilting the foot from side to side, kicking and looking mystified at the audience, like she also didn't know what was going on. This choreography was humorous and spectacular, creating a real surprise for audiences—they were not expecting that fashion could also make sound!

Figure 94. Choreographer Krõõt Juurak performing with *CEF P2*, during COS *Artstravaganza* show at *Modemethode* exhibition by Karl Lagerfeld, Bundeskunsthalle Bonn, 9 September 2015.

The piece represented another instance of the feet and shoes communicating something meaningful, extending the metaphor of the *Fashion Rules!* song, by communicating a love of fashion while being aware of its artifice.

Figure 95. Performing *head over heels* with *CEF P1* during COS Artstravaganza show at *Modemethode* exhibition, Bundeskunsthalle Bonn, 9 September 2015.

Krõõt's humorous performing style played against the serious rules of fashion. While she appeared to be playing the feminine model, she was actually disrupting the concept of feminine high-heeled shoe commodities while creating unexpected music.

Also, bringing attention to how the feet can be adorned with a musical instrument temporarily, offered a visual and conceptual instability and exploited the fact they were unlike 'normal' high-heels. Constructing them live on stage created a theatricalisation of the high-heeled shoe musical instrument, giving it agency. The shoe instrument became a prop, communicating emotional expression. For example, the act of putting on a musical pair of shoes required help. This exaggerates the act even further and even suggests a dangerous quality to the shoes, which supports the concept of 'unwalkable' high-heeled shoes presented in section 2.4.1.

The focus of this performance was using the *CEF P2* and not *CEF P1*, though I did want to see how the *CEF P1* could be used in the performance as well. Using both shoe prototypes in different ways during scenes of the performance, made the audience more familiar to seeing a foot-based musical instruments. The prototypes also afforded new playing styles and extra-normal foot movements as well as collective performance styles such as mirroring as seen in Figure 95. Although Krõõt isn't wearing the shoes in this scene, during some stages of the performance, there is a reflecting imagery style going on, me performing *head over heels* in the air and Krõõt performing balanced on one leg.

This performance also presents a good example of using props to create scene cohesion. Each scene is designed around the shoes which offer a bridge from one song to the next. The shoes help interconnectedness cross disciplinary mediums of the performance including pop song music, fashionable costume, FM sound synthesis and choreographed playing styles. These aspects are embedded in the shoes which impacted the dramaturgy of the whole live performance and conveyed deeper meanings to audiences.

Overall, each time I have performed with the prototypes I have learned something new. As a reflexive practitioner, my ongoing process of live enquiry and deliberation has facilitated new understandings, discoveries and unexpected outcomes. This *Artstravaganza* performance I have described, was the first time those past understandings could be reworked into a larger COS gesamtkunstwerk frame. Also, the infrastructure of the Bundeskunsthalle (larger stage, and specialist dancers, lighters and AV personnel), facilitated in general a more ambitious 'bigger' rendition of *foot-work* and performance with the shoes than I had previously experienced with other shows.

Now I will describe the iterative design development, artistic outcomes and performances with the final prototype of this thesis—*CEF P3*.

4.4.4 Computer Enhanced Footwear Prototype 3 (CEF P3)

As demonstrated in this chapter, my prototyping strategy is built upon understandings gained through prototyping iterations, performances and external feedback. It is also interwoven with my artistic method, which at times can be non-rational.

For me, approaching experiments in an artistic way helps lead me to unexpected outcomes and opportunities. This interconnected artistic method has a lot to do with the iterative design and fabrication of *CEF P3* which I undertook during an artist-in-residence with Autodesk, at Pier 9 Technology Centre, San Francisco, outlined below.

4.4.4.1 Ideating a Foot-Wedge

Figure 96. *Pole dance sneaker prototype*, 2D rendering, 2015.

Prior to taking up the residency, I ideated physical shoe form concepts to realise during the residency, including a half a sneaker sole with embedded circuits and neoprene upper (see Figure 96.). I was still working with the principle of a half-shoe, like the previous prototype, where the top of the foot and toes are free to facilitate possible actuation of toe sensors. I contemplated adding one pressure sensor under each big toe which could act as a trigger (changing the pre-set filtered sound palette in a MaxMSP patch). As well as adding a sensor on the heel for flexion data (to enable frequency modulation).

This first prototype idea for *CEF P3* would be an iteration on the *CEF P2*. I wanted it to be the next 'big thing' in pole dance footwear. I came to this assumption, through insights gained from working with Marla and seeing that pole dancers could benefit from a springy, more sporty sole, rather than cumbersome, sexy high heel plateaus. For *CEF P3* I wanted to explore creating a modified version of dance sneakers[172] specifically designed for pole dancers.

The ideation for *CEF P3* began at the cult Preylinger Library with its large collection of tech magazines from the 1980's and 90's. I was curious how the editorials featured new computer graphics programs, physical media and hardware developments from these decades. It appeared redundant and yet humorous, knowing that at the time of publication, this information must have been compelling, influencing graphic design styles and computer art of the time.

Of particular interest was an article by David Palermo (1991) highlighting the term 'blendo', which he described as computer art tools that encouraged the synergistic use of several programs. I discovered blendo was part of a movement that considered 'genre-bending', 'digital postmodernism', or 'synergistic art', as aesthetic ideas to come out of computer graphics programs. This resonated well with my personal artistic method of interconnectedness between cross disciplinary mediums.

Scanning further through the collection of magazines, I also noticed how new material technologies also influenced the presentation of digital media on which music is stored. For example, the Mylar® printed surface of the CD (compact disc), which the advert (see Figure 97.) seductively claims is the latest sexy and fashionable looking 'lazer technology'.

Mylar is a brand name for polyester resin, which is a type of clear, thin plastic. The foil-covered Mylar used to make balloons and other shiny products is an extremely thin layer of aluminium metal (less that 1/100th of the width of a human hair in some cases). It has since been commercialised and used to coat fashion accessories. I was drawn to this connection between an outdated music distribution vessel and it's superficial looking coating (the added coating on a CD was decorative and served the purpose to reflect the

[172] Such as the Capezio dansneaker® or Bloch Boost dancer-style sneaker.

beam to convey the data information embedded on the under laying transparent compact disc).

Figure 97. Panavision lazer technology advert featuring Mylar coated discs, Compute! Magazine (1991).

After gaining new understandings through the literature, my objective was to see what would happen when this knowledge informs the 3D fabrication. Using the latest state of the art technology at Autodesk, I would make a physical prototype using the following themes to inform the 3D designing and printing process of *CEF P3:*

- adopt a 'blendo' style of synergism to inform prototype material and agency
- allow the technology to drive new aesthetic materials in art-making
- use 3D printing to nurture free creativity and foster a more humanistic way of working with digital fabrication processes to facilitate a warm outcome
- new understanding of using 3D printers can extend the technologies involved (Candy 2002) into new artistic forms.

4.4.4.2 Hacking the 3D printer

The exploratory process of prototyping *CEF P3* began with creating a 3D rendered quad mesh of a foot wedge in Fusion 360 CAD (computer aided design) program. The wedge went through a series of modelling steps, including slicing off the front of the wedge and closing the mesh (see Figure 98. and Figure 99.).

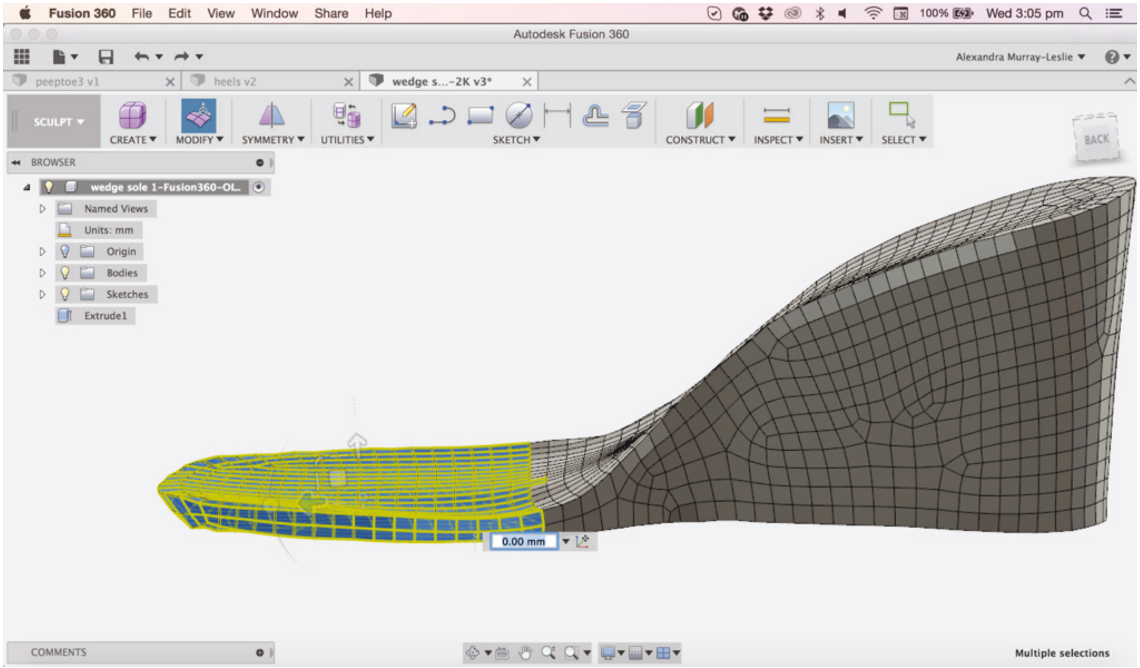


Figure 98. Quad mesh 3d rendering of foot wedge in Fusion 360 showing area to be cut off enabling free movement of the toes upwards and downwards.

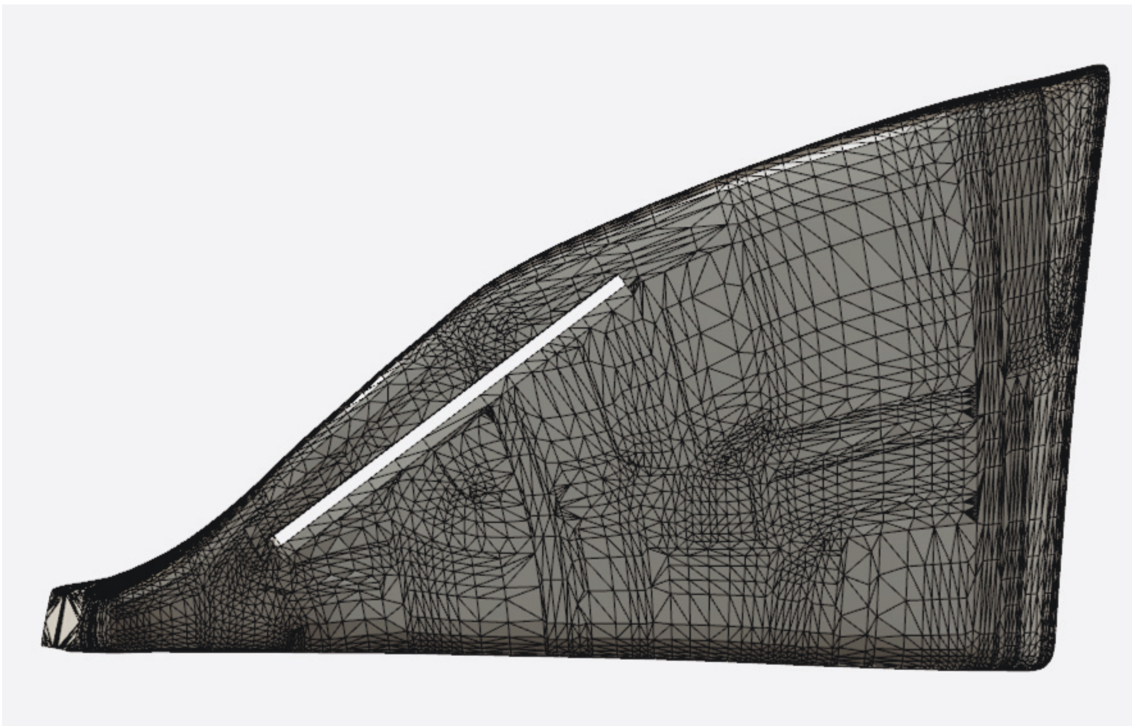


Figure 99. Finer mesh 3D rendering of foot wedge with closed toe, smooth surface

I then exported the model as a STL file for import to the Fortus 380mc 3D printer, to create a low-resolution prototype using PLA[176] (see Figure 100.). This would be used to test the strength of the foot bed and arch, determine if the prototype could hold my body weight and whether it aesthetically looked good. After the initial successful low-resolution (res) print on the Fortus printer, I then moved on to experimenting with the Connex™ Objet500 3D printer.

Figure 100. Low resolution 3D printed foot wedge for checking foot bed, structural stability and aesthetics.

My goal at this stage, was to make a new type of 3D print material (see this process video, which also became a scene in two music videos, https://vimeo.com/282677277. To do this, I cut short strips from various coloured Mylar film (see Figure 101.) and made a simple test 3D printed disc (see Figure 102.). I laid the Mylar onto the print, half way through the process (after the support material), to ensure the printer would not crash[177] during the print job.

[176] Poly lactic acid (PLA) is a bio-degradable type of plastic.
[177] The new layer thickness created by the Mylar film could potentially interfere with the filament extrusion print heads, rollers and UV lamps of the printer and cause it to fail.

The initial tests were successful, and I was given the go ahead by print shop lead Gabrielle Patin (though without polishing the surface, as I was still unsure whether this Mylar embedding process would prove effective).

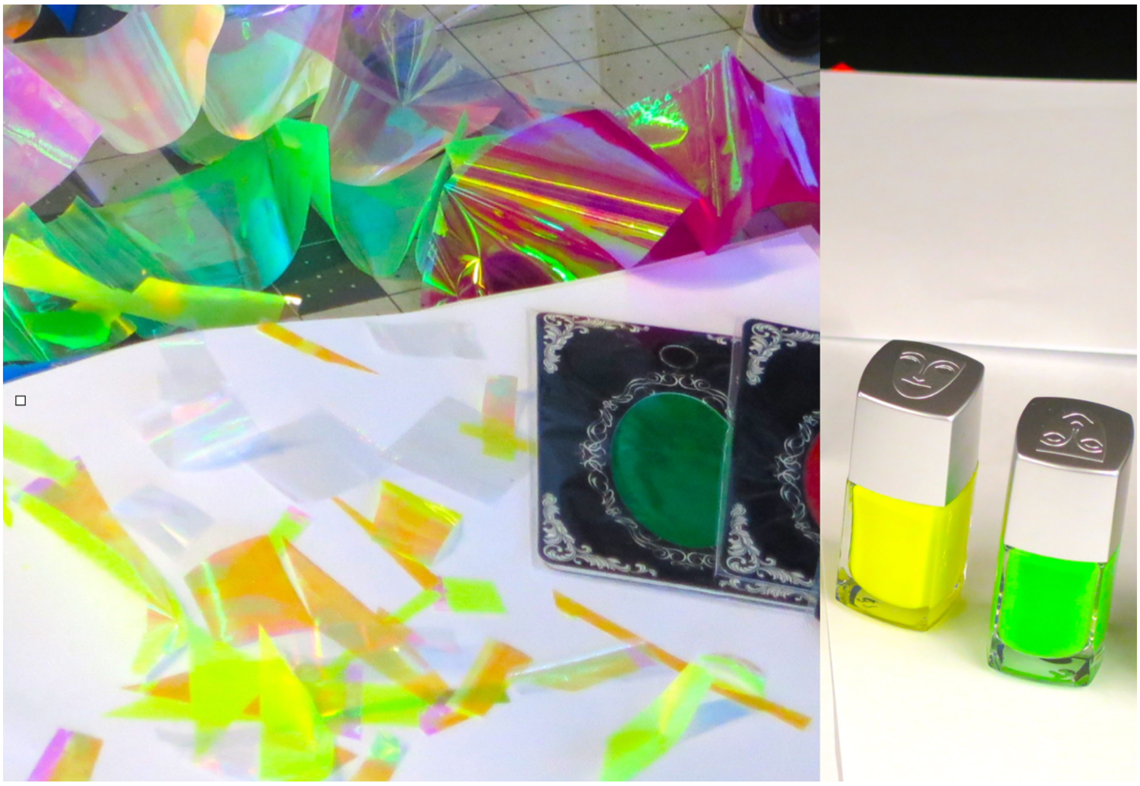


Figure 101. Strips of Mylar film cut into uneven sizes and Kryolan UV nail polish to be used as print in-lay.

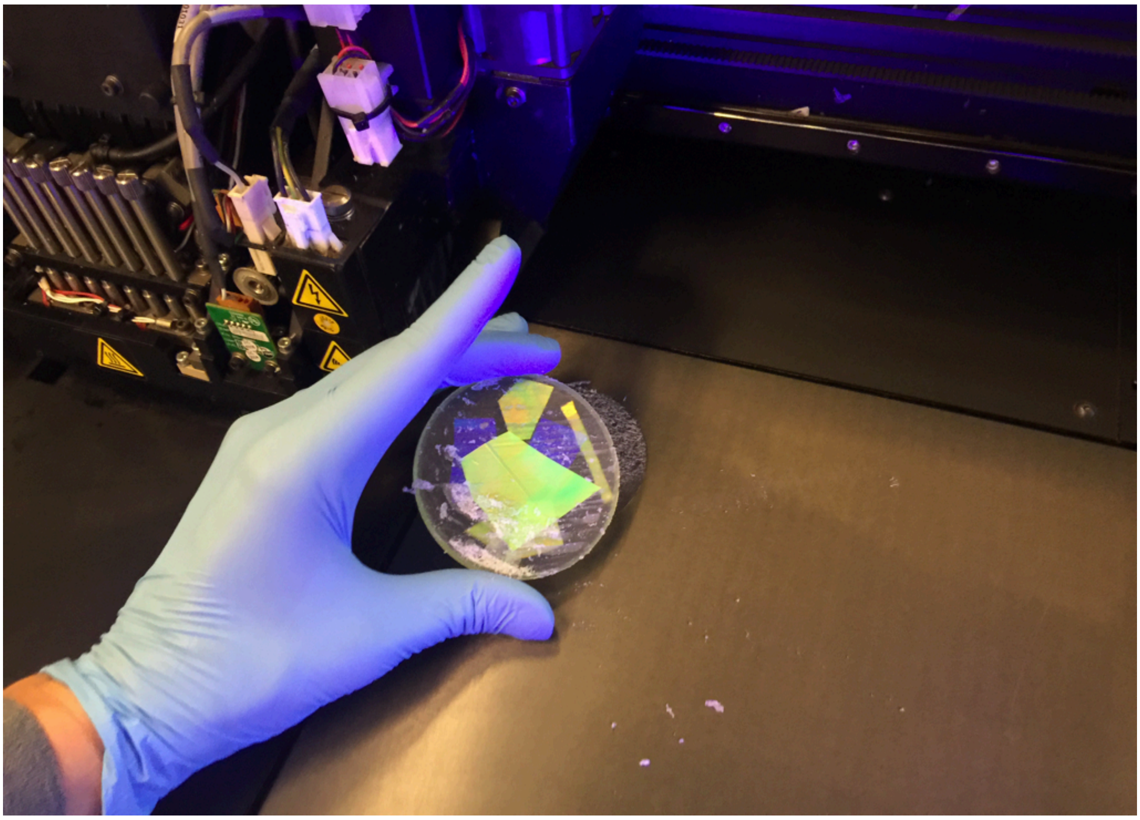


Figure 102. Strips of Mylar film cut into uneven sizes used as in-lay in between print slices of circular disc, during 3D printing process on Objet Connex500 3D printer.

Figure 103. In-laying strips of Mylar film during 3D printing process.

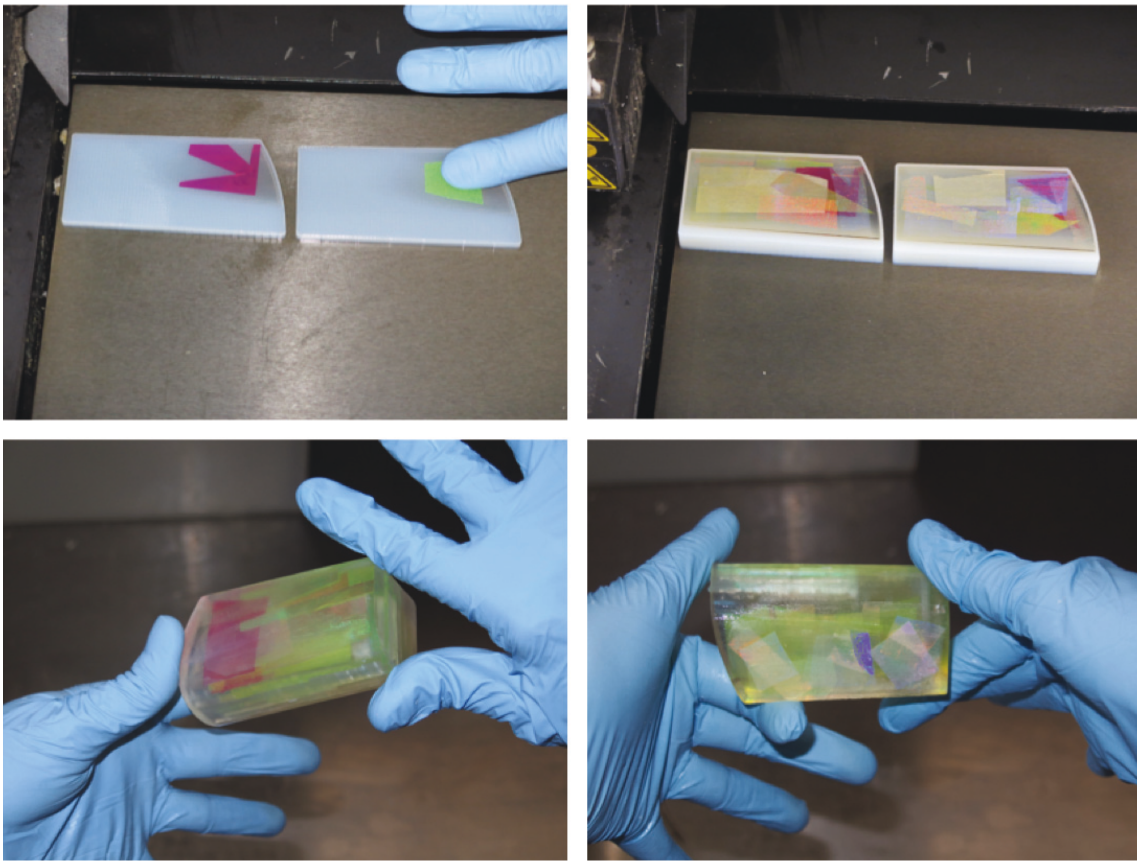


Figure 104. Stages of printing with Mylar in-lays. Top left: adding Mylar. Top Right: building layers of Mylar every 10 print slices. Bottom left and right: washed 3D print showing Mylar in-lays.

Continuing the physical interventional experiments with the 3D printer[179], I referred back to the STL file used for the second 3D printed heel of the *CEF P1* and created a closed wedge heel with an internal cavity for the circuits, sensors and battery (the same circuit and system embedded in the heel of the *CEF P1* and *CEF P2*). This new wedge heel would be re-movable and re-attachable for battery charging after performances.

Through my printing exploration I had now developed a personal system of embedding the Mylar, which I tested on two wedge heels:

1. print support material
2. print 100 slices of transparent PLA print filament

[179] It is important to note, the way the experiments were conducted, pausing a print job and opening the 3D printer midway, usually would not be permitted in everyday contexts of using Objet Connex 500 3D printers. However, working with the expert, trusting team at Pier 9 (who are notorious for taking risks to make new forms of art), I was very well supported in my experimental endeavours with this state-of-the-art machine.

3. pause the print job and randomly lay down the Mylar film (which had been cut in an uneven choppy fashion)[180]
4. continue steps 2 and 3 until print is complete.

After repeating this process for 1000 slices, I noticed that the sizes, configurations, surface textures and colours of the Mylar I had embedded in the filament were creating diverse luminous and reflective effects. The more random layers of Mylar colours and surface designs I laid down, the more illusionary and multi-dimensional the material was becoming (see Figure 105.). Also, the effect changed depending on what angle you looked at the heels from.

The process of printing the foot wedges was a long task. While the print would normally take around 8 hours, because I was pausing the printer to in-lay the Mylar, this increased the printing time to 16 hours. Reacting to this long repetitive process, I decided to interact with the print, and 'play' with it, seeing the print bed as a stage for relational performance.

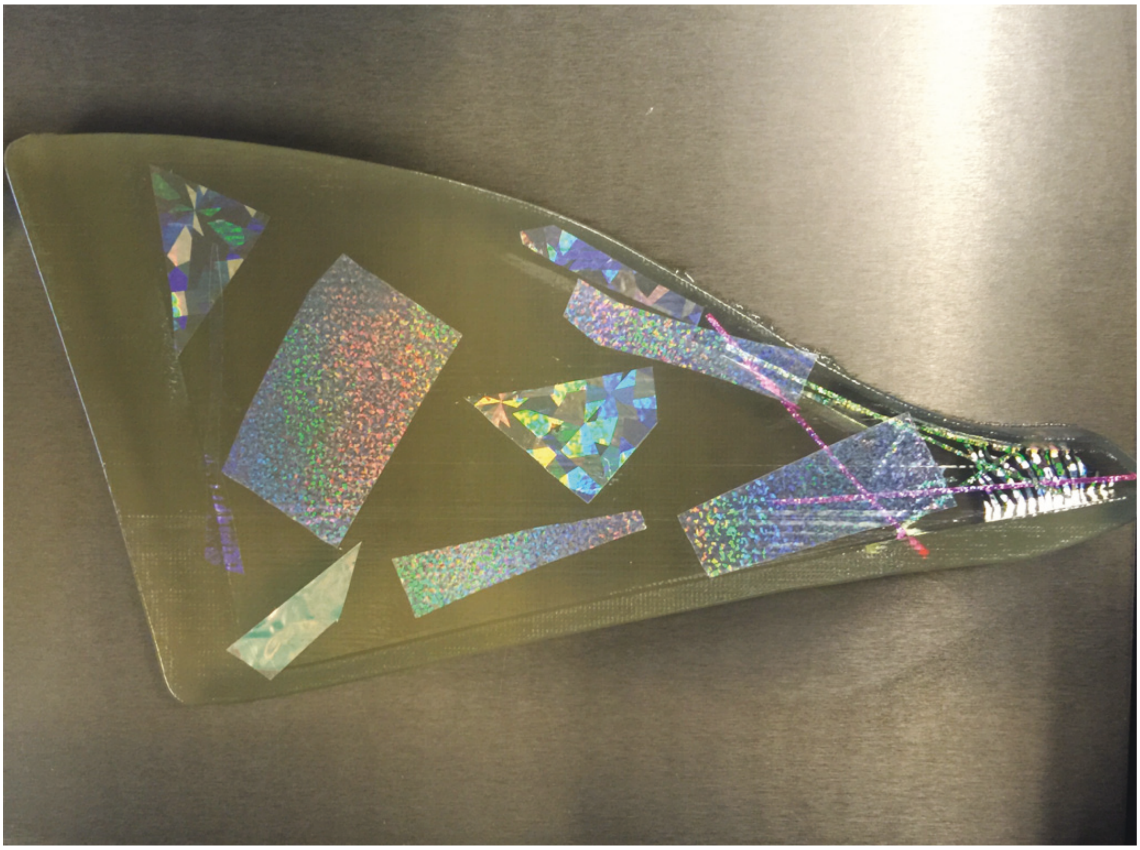
I began performing with the footwear whilst they were being made. It became like a pre-performance of the prototypes, me evoking bodily and foot gestural interaction with the 'cyborg' printer. I termed this playing style with my shoed feet *3d printeractivity*.

I photographed and filmed the printing process with a GoPro camera, whilst the shoes were being made. Following on, during the rest of the printing process, I began taping areas around the 3D prints using high viz and coloured duct tapes, performing physical choreographies intermittently when the print job was on pause (see this video scene: https://vimeo.com/193838591).

The process of working in the fabrication laboratory whilst 3D printing the foot wedges also developed the following new-found artistic and documentary opportunities:

- 2 self-made music videos for the song *We are Data Remix*[181]
- Collaboration lens-based work *Performing 3dinteractivity* with Steve Mann[182], (see Figure 106. and this video: https://vimeo.com/282669559/69917c4b16).

[180] See video link of Mylar inlaying 3d printing process:
[181] *We are Data remix* music videos directed by Alexandra Murray-Leslie, music by Chicks on Speed and Cora Nova, 2017 (see: https://vimeo.com/207064196/04df14ac93 and https://vimeo.com/278296841/580996ce22).
[182] I collaborated with fellow AIR Steve Mann, on a performative lens-based work, using his invented process of Phenomenological augmented reality (http://spectrum.ieee.org/geek-life/profiles/steve-mann-my-augmediated-life).



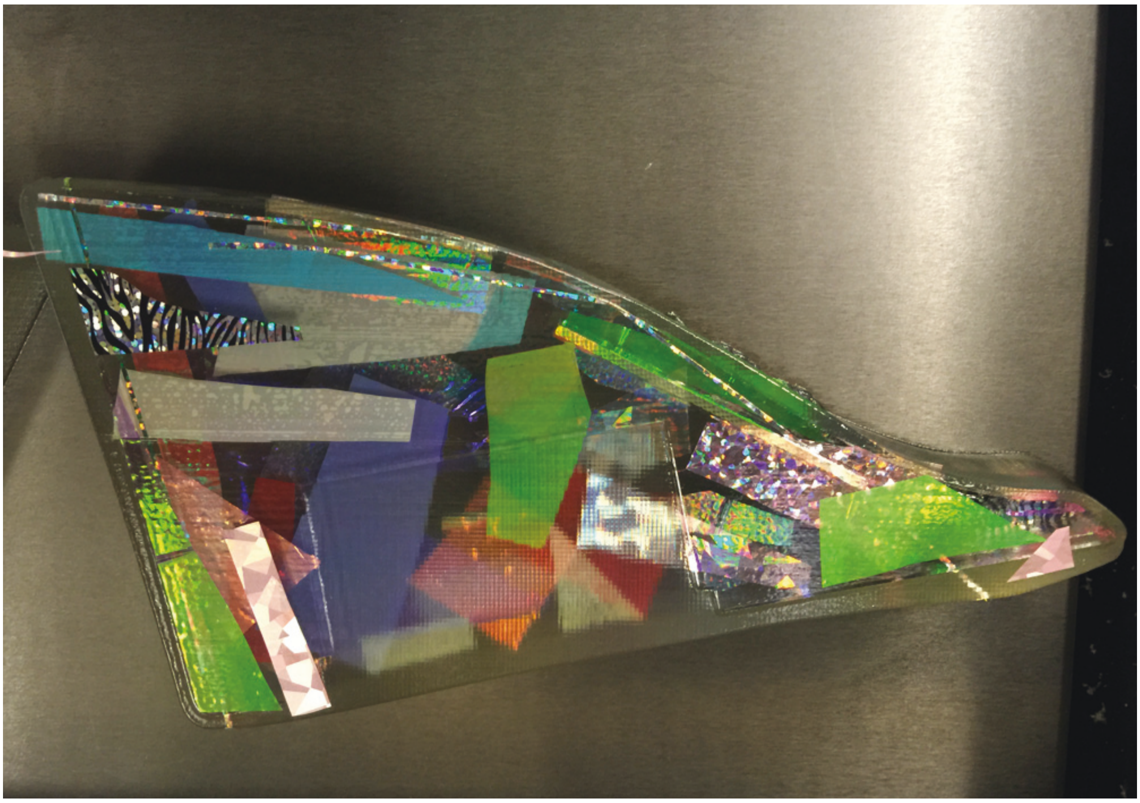


Figure 105. Two versions of the *CEF P3* foot wedge. Mylar was inserted into every 100 print filament slices to create a material with a multi-layered, reflective effect.

Figure 106. Performing *3d printeractivity* with the Objet Connex500, a cyborg craft collaboration with Steve Mann, Autodesk, Pier 9 Technology Centre, San Francisco, 2016.

After I completed printing the wedges, I began the long process of sanding out surface imperfections and polishing them[183], which took three days. The finished foot wedges looked very different polished (see Figures 107. and 108.)

For exhibiting purposes, I installed the *CEF P3* prototypes on the on the 3D print 'stage' where they were made, (see Figure 109.). Poised like shiny foot commodities, I finished them off by attaching high visibility braiding and reflective duct tapes, to allude to how the shoes might be attached to the foot.

[183] Guided by Noah Weinstein's (2012) instructable http://www.instructables.com/id/How-to-Polish-Resin/

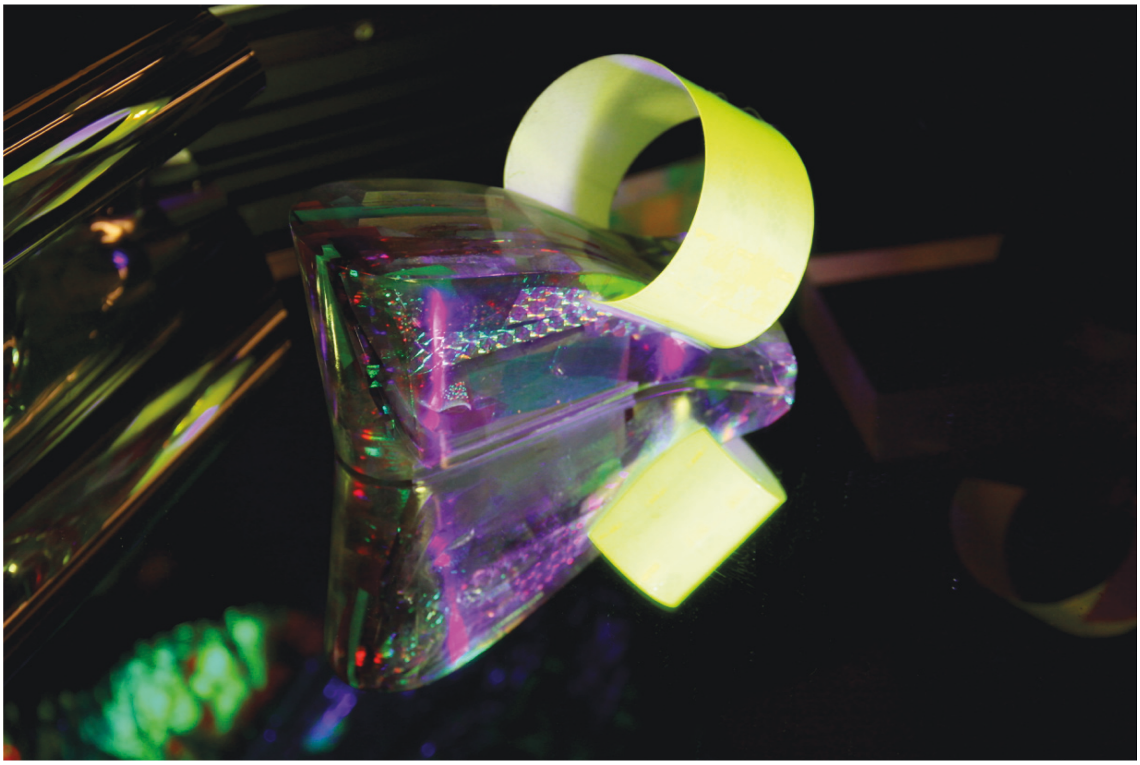


Figure 107. *CEF P3*, rear view.

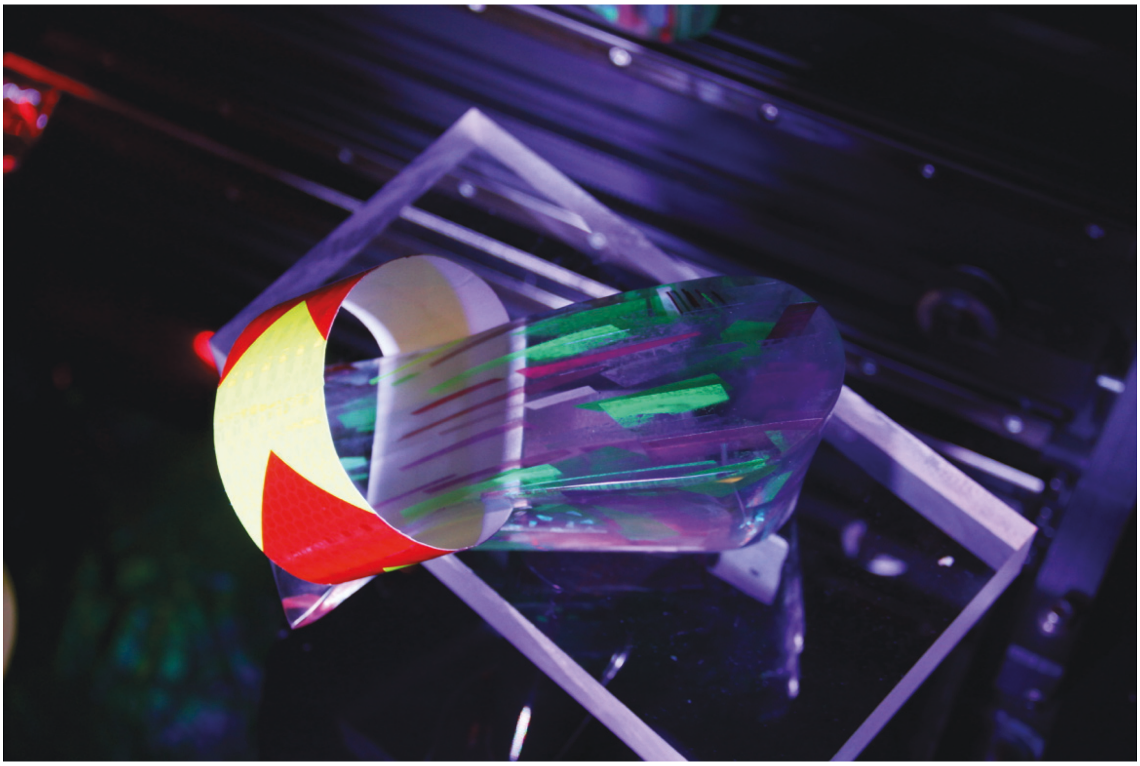


Figure 108. *CEF P3*, top view.

Figure 109. Installing *CEF P3* on Objet Connex500 3D printer for *Open Air* exhibition, Autodesk, Pier 9 Technology Centre, San Francisco, December, 2016.

Figure 110. Left: *CEF P3* worn by dancer Elizabeth Bressler in the *We are Data remix* video. Right: Completed *CEF P3* print with Mylar in-lay and reflective band, Autodesk, Pier 9 Technology Centre, San Francisco, 2016.

While this work started from literature, theories and technical methods of using CAD and CAM—it was personally playing, positively disrupting (or making strange) and re-imagining state-of-the-art machinic technologies, materials and design precedents—that was core to getting results in my practice-based research.

My initial aim to create 'warm' or 'humanistic' outcomes were achieved through intervening in the perfect print process, by having a human manually and randomly, in-lay coloured mylar elements in the object. Rather than being regarded as incidental or antagonistic to the finished product, the surface imperfections typical of the newly fused deposition of mylar during the 3D print process have been used as an opportunity to produce unexpected, holographic effects.

The slow 16-hour process of printing also led to reflection-in-action experimental processes that informed unexpected outcomes, unusual extensions of outputted media and alternative models for using technology. I built a new relationship with the technology and performed with the 3D printer, which challenged formalist orthodoxies embedded in 3D printing and created "experimental amateur scientific practice as an artistic practice" (Cantrell 2016).

Akin to my experiences with *CEF P1* and *CEF P2*, *CEF P3* also had the ability to become communicative props with semantic value. The new prototype was able to transmit deeper meanings through its aesthetic design and via sound and gesture during performance. Overall, it was during performance that all of the shoe devices made most sense, especially the case during the performance fabrication of *CEF P3* which manifested as live performance art, lens-based artworks and music videos. These different mediums of expression were interconnected by acts of using the feet in different unexpected ways.

In the next section, I will outline further case studies of performing with CEF P3 to develop new types of imaginative foot expressivity.

4.4.4.3 Performing foot-based experiments with CEF P3

***ECOcyborg*, YoMo, Mobile World Congress, Barcelona, 27-28 March and 1-2 April 2017, https://vimeo.com/murrayleslie/ecocyborg-mobile-world-congress-barcelona**

As artistic director of Youth Mobile (YoMo), Mobile World Congress in Barcelona, I had an opportunity to stage a show at the mobile phone fair with my *computer enhanced* *footwear*. *ECOcyborg Fashion-Tech Show,* was a 15-minute, wearable technology fashion show that showcased *CEF P3* and a series of wearable technology inventions by Steve Mann.

The catwalk style show took place inside the Barcelona fair grounds with 16,000 visitors daily, all hungry for entertainment. The *ECOcyborg Fashion-Tech Show* comprised of four scenes, which were each presented in front of 1000 people multiple times per day. Each scene featured a different wearable technology invention, performed with a bespoke collage of electronic pop beats, audiovisual costumes, styling and choreography. For this performance, my upper body costume[187] was designed around the *CEF P3*'s material elements of in-laid reflective Mylar and neon tapes (see Figure 111.).

Figure 111. Performing *CEF P3* in horizontal mode to the *We are Data Remix* song, ECOcyborg Fashion Tech Show, *YoMo*, Mobile World Congress, Barcelona, 27 March 2017.

I performed *CEF P3* to the *We are Data Remix* song, in a comparable way to how the *Pre-prototype (BipedShoes)* were played to the song *We are Data* (see section 4.4.1.2.).

[187] See Appendix F: Project Acknowledgements.

Performing over the top of the bass-heavy beats of the song, the foot apparatus created a palette of juxtaposing, live atmospheric sounds. These sounds embodied the concept of *We are data* (the data the people leave behind through online, communication and transaction activities[189]) and were expressed through exaggerated digital resonances or floating sounds during the performance. For this show, *CEF P3* used the original circuit from *CEF P1* and the original system, now on version 4. With this version, I was able to pre-program the sounds by saving the desired sounds to specific pre-set buttons in the max patch.

My body lay on the side, perpendicular to the stage (a position that I had performed in during *Look Therapy-All Over Over All)*, which enabled me to change pre-sets in real-time with my hands, while my feet and legs performed at different angles and extensions to trigger sounds. Also, given this performance was a fast-paced wearable-tech fashion show, the *CEF P3* were used more as audiovisual styling elements. I began the song by playing the shoes as I walked down the catwalk (singing and interacting with the audience as I walked).

The shoes were mainly used to create a 'wow factor' to engage the mobile phone fair crowd in short bursts. The performances were only 3-minutes in length and were performed three-times-a-day over four days to sold out audiences. Overall the shoes functioned in a fast, direct and entertaining way, gaining great media attention across various online and offline platforms[191].

Analysis of Practice

- *CEF* can have the potential to influence the overall narrative, costumes, sound scape, scenography and dramaturgy of a larger wearable technology fashion show performance.
- The fashion-tech catwalk show was a good context to showcase the shoes directly in a more simple fashion, than previous bigger performances.

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[189] The *We are Data* song is closely linked with ideas of 'data shadows' or 'data footprints', see Howard (2005) and Zook et al. (2004).

[191] See Appendix A: List of public events with *Pre-prototype, CEF P1, CEF P2* and *CEF P3*.

Figure 112. Performing *CEF P3* in gravity mode to the song *We are Data Remix*, song, ***ECOcyborg Fashion Tech Show***, Mobile World Congress, Barcelona, 27 March 2017.

- Using styling elements on the shoes, like neon and reflective tapes further enhances the visual spectacle of the shoes, drawing the public's eye to the feet.
- The shoes require adequate lighting (black lights are not enough) so they do not get lost on stage.
- Arranging the sounds of the *CEF* to play on top of a pop song, complemented the messaging of the song and performance.
- Playing at a technology fair was a new-found opportunity to showcase the shoes and reach new audiences.
- The shoes communicated complex ideas within a traditional three minute pop song timeframe.

Through surveying the documentary material and various media of *ECOcyborg Fashion-Tech Show*, I formed new insights from performing the *CEF P3*. I came to the realisation this prototype needed its own set of dedicated sounds actuated through a different playing style (not using the *CEF P1* system). I wanted the *CEF P3* to do more than create stylistic atmospheres over the top of other songs. My aim was for the *CEF P3* to have a system that would facilitate rhythmic patterns, like a solo instrument that other instruments would play to, a sequenced beat.

I also realised I wanted the sounds to be in sync with some sort of expressive lighting effects in the shoes[192]. Looking at the images and photos from the Mobile World Congress performances, I could see the shoes got lost on the dark stage at times and I hasd to rely on performing with exaggerated movements to made it visible to audiences that 'something' was going on with the shoes.

It is at this point, that I started a conversation with Sergi Jorda and the Reactable team about developing a dedicated *CEF P3* system. I also reached out to Sebastian Melia from Protopixel regarding expressive lighting. In these next sections, I will explain how I developed and tested these system and lightening developments through a series of performances.

[192] Though I hadn't originally thought to put lighting into these shoes, it seemed to really make sense now as the shoes were transparent. Also, thinking back, so many of my interviewees had said they couldn't see that the shoes were doing something on stage and needed lighting, so it really seemed like a natural progression.

4.4.4.4 Reactable feet: Developing the new system

In the previous section, I described how I used the system from *CEF P1* inside the new *CEF P3* prototype and how this system did not adequately embody the visual style of the new prototype. I realised each foot appendage prototype should have its very own interconnected visual character, playing style, costume and audible language to become a successful NIME.

With this task in mind, I collaborated with Reactable[194] to redevelop the system for *CEF P3*. In doing this, I built on some of the original system ideas and created the following shoe movement categories for the new system:

1) One minute voice samples in Abelton Live.
2) Trigger sample via foot swing or kick (accelerometer).
3) Sample plays using simpler[196] (slicing up sample, generating melody).
4) 4 layers of separate voice samples pre-sets in Max/MSP – switching to new layer automatically and interfacing with Abelton live.
5) Layers are randomised Max/MSP.
6) *Composing, de-composing and re-composing*: build up live sound palette and composition, each time a new layer is generated, the previous 1st layer is deleted, so the composition builds and samples and melodies change within the 4 layers of vocal sliced pre-set (its possible to keep adding and then also taking away).

I also knew that if I was going to make this new system really work (plus the new lighting—more on this soon), I would need to test them during performance. Adding to this, I was invited to perform with the shoes at Ars Electronica Festival in Linz, Austria, which created a deadline to get the new features up and running. Ars Electronica Festival is the mecca event for art and technology plus the theme, 'Artificial Intelligence', was extremely fitting. It seemed like the perfect grand finale to my research journey.

I generally find it advantageous to work to a deadline, as the pressure brings things out in my artistic practice. Plus, having performance projects to test my

[194] For further information visit http://reactable.com/
[196] For further information visit https://www.ableton.com/en/blog/simpler-and-sampler-pro-tips-and-techniques-slynk/

prototypes provides me with an opportunity to explore in-the-moment outcomes and a way to work and interact with others.

With the Ars Electronica Festival deadline looming, the plan was to test the sound system at Yo Sissy Festival in Berline during the COS's headline performance and then integrate the lighting before taking *CEF P3* to Linz.

Chicks on Speed performance at Yo Sissy Festival, Berlin 29 July 2017

https://vimeo.com/murrayleslie/cefp3chicksonspeedyosissy

Figure. 113. Performing *Fake News* introductory scene with the feet; *Horizontality-foot-kicks* playing style, Chicks on Speed live, Yo Sissy Festival, Berlin, 29/07/2017

For this COS performance, 'Fake News' was used as a conceptual frame through the costume design and shoe sounds. Newspapers featuring fake news stories and articles, were folded and layered onto our bodies as temporary costumes and a rhythmic composition was created using voice samples collected from supposed fake news stories.

I walked on stage with amplified footsteps, building up the anticipation of the audience and bringing attention to the feet and shoes as loud sound generators. I then climbed onto the road case pedestal and began playing *CEF P3* by triggering some of the choppy vocal samples with fast foot kicks. This took great physical effort and abdominal strength, not unlike playing some classical musical instruments.

Gradually Saskia came in on drums, accompanying me with an offset beat to the sample palette of voices, with me setting the pace and base composition of the piece. Melissa accompanied us on alto saxophone her personal limber style. Her ethereal notes floating on top of the shoes rhythmic vocal sample layers and off-beat drum patterns, she played some Turkish inspired parts (an eastern scale), adding an interesting tonal quality to the piece.

We continued our improvisation of composing and re-composing the piece for just over four minutes (3.50 minutes is the length of a standard pop song, which is usually the attention-span of live audiences from my experience).

Analysis of practice

- The role of hands and feet in a NIME or classical musical instrument performance is reversed. The shoes become the main instrument of focus in the 'Fake News' scene. Successfully moving the attention of traditional classical musical instrument playing from the hands to the feet.
- The other classical instruments relied on the shoes to set the rhythm and base of the piece from which to improvise.

There was some latency during the show between the kicking movement of the feet and sound actuation which affected the performance of the shoes. It put me off, rhythm-wise as I was kicking, as the sound was actuated one second later. However, as there was so much going on stage, the audience did not seem to notice and received the performance with surprise and fascination.

I found it quite difficult to maintain the movement and momentum of kicking constantly into mid-air (something that would in future require some physical training and rehearsal). Therefore, upon reflection, it could be better in future to develop a different *CEF P3* playing style, possibly one that utilises a suspended position (in air or water), affording the feet a larger kicking and leg lifting range, with extended periods of actuation.

All in all, the Yo Sissy event was a successful 'live-rehearsal' for the upcoming Ars Electronica Festival performance. Now it was time to go back into the lab for the next iterative step of the prototype: shoe luminance.

4.4.4.5 Foot Illuminations

I embarked on the final phase of the *CEF P3* shoe development, by working together with Protopixel[199] to embed multi-colour RGB LED (red, green, blue light-emitting diode) strips into the shoes.

This required having a dedicated circuit, around the same size as the *CEF* P1 circuit, though slightly longer, which meant I had to modify the size of the space in the wedges. I did this by carving it out with a hand-held Dremel rotary tool.

Then I experimented with a coloured sequences of lighting effects and chose different pre-set settings that would utilise random colour combinations. This would make the lighting seem unrepeatable to audiences, mirroring the Reactable sound system, which was always changing and never repeating older vocal sample sequences. Just like the sounds, the lights also responded to the movement the foot kicks and swings (the accelerometer sensor), which actuated the pulsating light of each pre-set light effects channel. I addition the pre-set patterns were switched randomly when there was a big movement of the feet.

The RGB LEDs had the following four pre-set light effects (see Figures 114. to 117.) that could be triggered in Max/MSP in sync with actuating areal kicks and vocal sample layers[201]:

1) Single pulsating colour (brightness-soft to intense)
2) Randomised multi-coloured light glow
3) Colour play (3-way colour transition)
4) Light flash (white light or coloured light).

[199] See Appendix F: Project Acknowledgements.
[201] See these videos which demonstrate my light effects tests:
https://vimeo.com/murrayleslie/cefp3colourtest1, https://vimeo.com/murrayleslie/cefp3colourtest2.

Figure 114. Testing colour changing light effects: light effect 1.

Figure 115. Testing colour changing light effects: light effect 2.

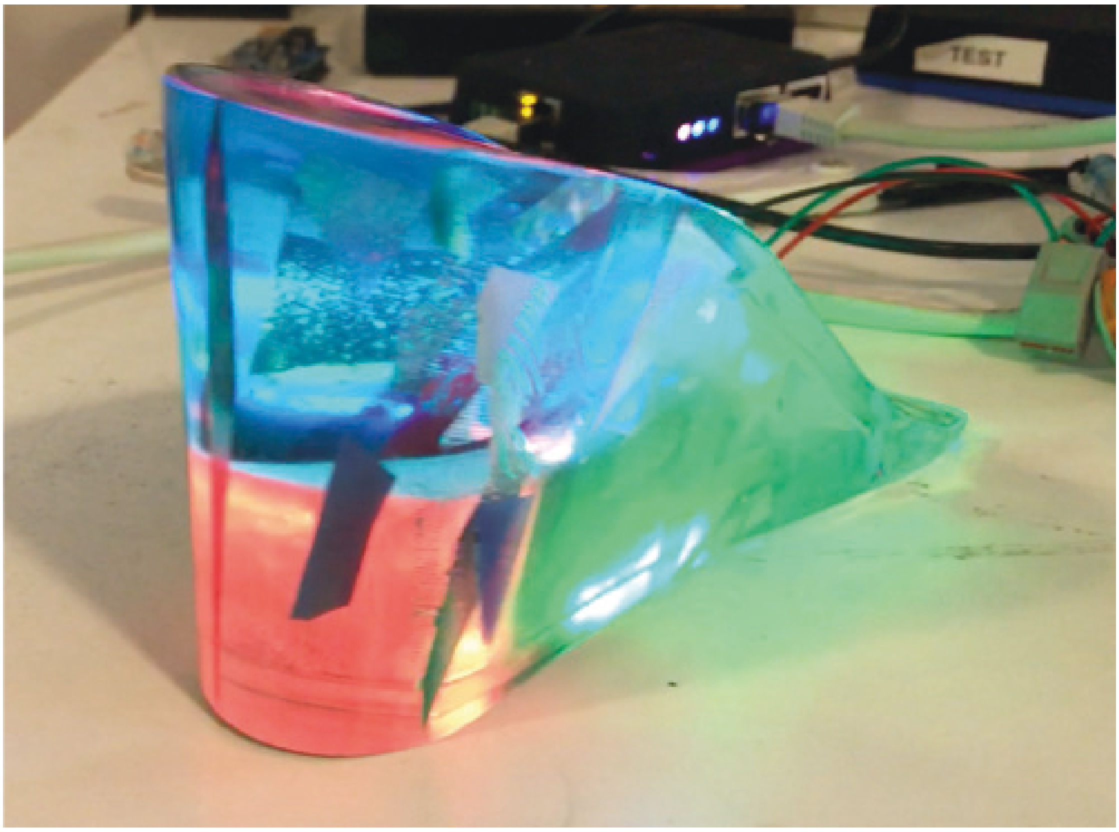

Figure 116. Testing colour changing light effects: light effect 3.

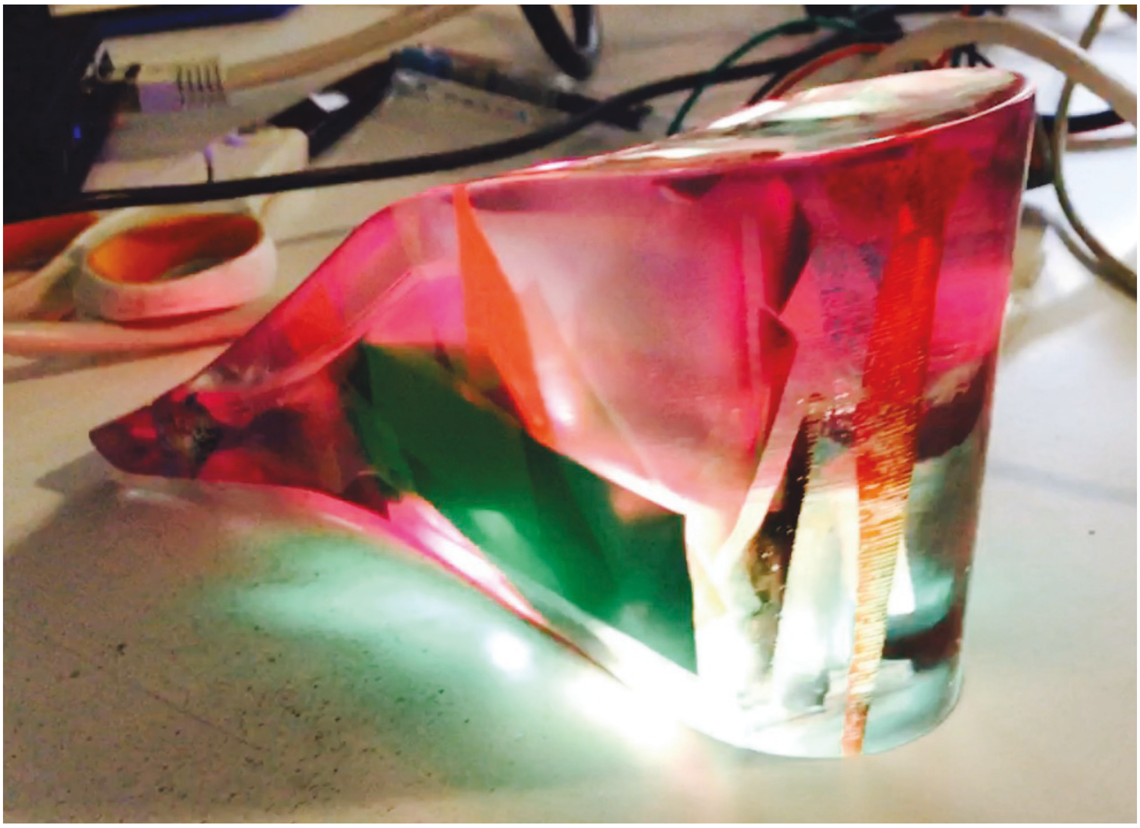

Figure 117. Testing colour changing light effects: light effect 4.

Analysis of practice

- Luminous compositions made by the feet present:
    - a new layer of interest to the Prototype *CEF P3*. It becomes more beautiful and multidimensional, with different light reflective qualities.
    - the artefact becomes more interesting.
    - more discovery value for a viewer (each angle is different, with the mylar and unpredictable light refractions, reflections)
    - different kind of artistic foot expressivity.
- Unpredictable, unrepeatable lighting effects and rhythmic sound patterns surprise audiences, providing a new language of the feet that is different.
- Integrating lighting effects in *CEF P3* prototype was not planned, it just happened in a natural progression of the artistic practice. This supports concepts of an interconnected artistic method for designing a foot apparatus being:
    - Cross-disciplinary
    - Un-rational and messy
    - Supportive of unknown artistic outcomes and opportunities led by the foot apparatus (and what looks and sounds good, building additional layers to make it more interesting).

4.4.4.6 The main event: Performing at Ars Electronica Festival

The performance for Ars Electronica Festival was short, only 15 minutes. The show had the following three acts to showcase *CEF P3* and COS songs:

1. Introduction: *composing, de-composing and re-composing* with *CEF*.
2. *We are Data Remix* (COS).
3. *My Mind is like a Plastic Bag* (COS).

During the introduction, the shoes acted as solo instrument. Vocal beats triggered by the feet in a loop of composing (starting off simple with one layer), de-composing (taking layers of chopped vocal samples away) and re-composing (adding layers of chopped vocal samples). For the song *We are Data Remix*, we performed acoustically to paint atmospheres over the top of the playback track, triggering intermittent snippet sound effects, which sounded like vocal glitches. For *My Mind is like a Plastic Bag* [202] the shoes were used to trigger lighting effects with the sound muted. Taking inspiration from this last song, the show thematically evoked an ironic celebration of all things plastic.

Figure 118. Performing *CEF P3* playing styles: *Oblique Foot Crunches* and *Chorus Girl Leg Lifts*, Ars Electronica Festival, September 2017.

My plastic-style shoes were combined with upper body costumes made of large pieces of Mylar in combination with Tyvek—a synthetic material, often used in construction and HAZMAT (hazardous materials) applications, such as asbestos and radiation work. I like this relationship between a stage costume and workwear (ideas that were also evoked in past performances using high visibility tapes as a kind of work wear for the feet).

The Mylar and Tyvek were constructed into lab coats, with transparent Mylar sections matching nicely with the shoes. Three irregular sized silver clad tetrahedrons, made by artist Boomesch Tak added a spectacular esoteric essence to the stage setting and interacted well with the silvery coloured mylar in the shoes and lab coats.

[202] For interest, our song is a remix of the Minty song *Plastic Bag*. Minty's song is based on Xray Spex's 1997 original song *Plastic Bag* https://www.youtube.com/watch?v=MFv53VolRj8.

Figure 119. Performing *CEF P3*, Ars Electronica Festival, Linz, September 2017[207].

Figure 120. Performing *CEF P3* in *Gravity Position*, Ars Electronica Festival, Linz, September 2017[209].

[207] Image features artistic long exposure photography of *CEF P3*. See Appendix E: Project Acknowledgements.
[209] Image features artistic long exposure photography of *CEF P3*. See Appendix E: Project Acknowledgements.

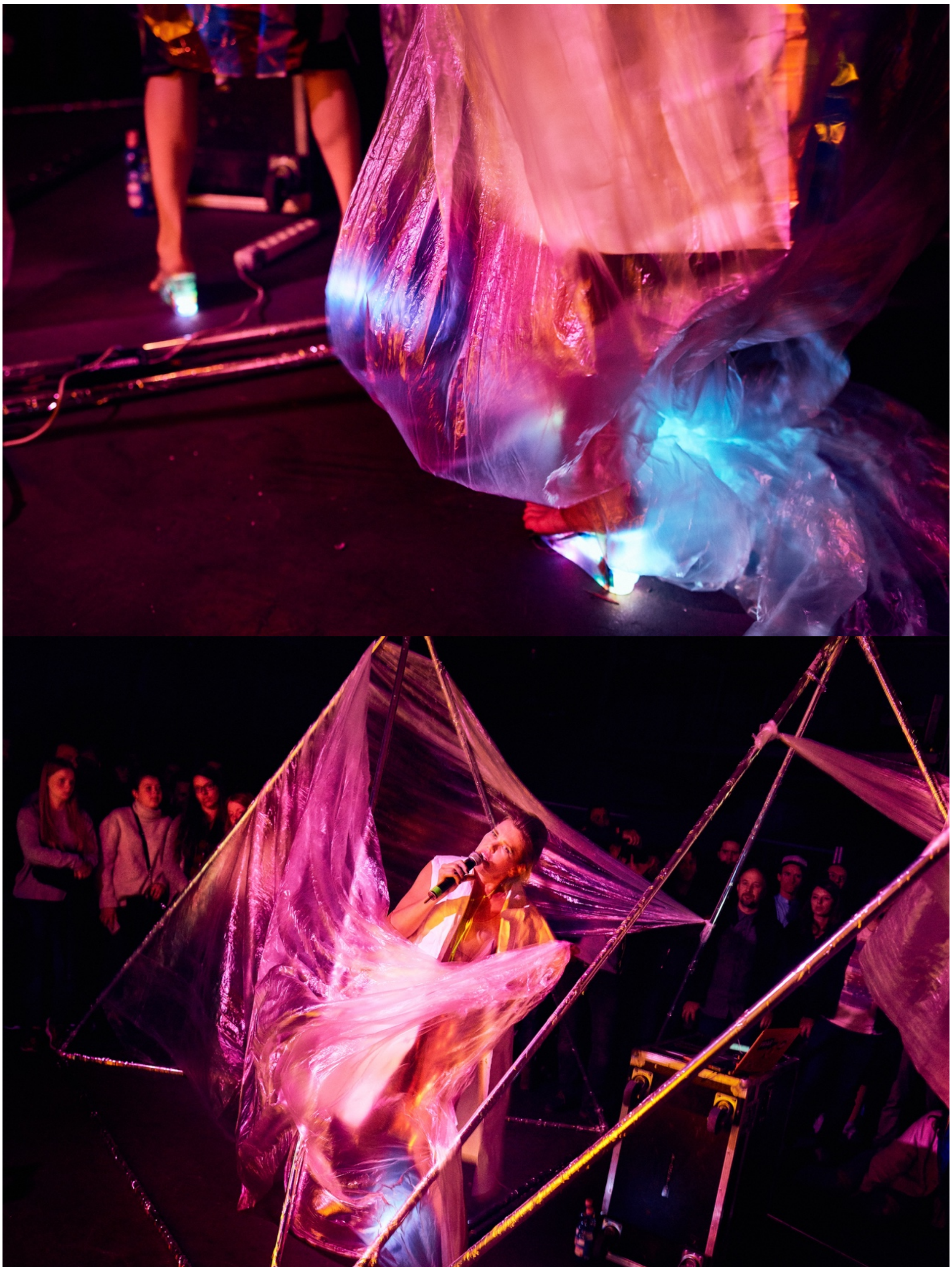

Figure 121. *CEF P3* illuminating multi-coloured light effects on plastic,
Ars Electronica Festival, Linz, September 2017.

Adding to these costumes and scenographic elements, a large piece of frosted PVC plastic sheet (common in hardware stores and workshop environments) was introduced half way through the set, floating in the air and then stretched across the tetrahedron facets, forming a tent like structure. The shoe's pulsating light effects diffused through the milky plastic (see Figure 121.) produced an interplay between the shoes, rhythmic vocal beats and illuminance of architectural space.

The following is a breakdown of the playing styles of *CEF P3* used in the Ars Electronica Festival performance:

1. Introduction: *composing, de-composing and re-composing* with *CEF*
    a. *Horizontality*: Lying sideways on pedestal like stage cases, holding onto tetrahedrons for stability, they acted like a swing, with both arms outstretched (see Figure 118.)
    b. *Chorus Girl Leg Lifts*: Krõõt performed exaggerated high leg lifts, chorus girl style (see Figure 118.) hands stabilising rest of the body.
2. *We are Data Remix* (COS)
    a. *Kick-backs*: moving through the space in gravity position, in an expressive walking fashion, 'body malfunctioning'[212], bodies twitching, holding tetrahedrons and kicking legs backwards in the air, triggering light effects and samples (see in Figure 122.).
3. *My Mind is like a Plastic Bag* (COS)
    a. *Gravity Position* (see Figure 122.): standing up-right moving in the shoes, we worked on building a tent like structure together and performing inside it. Inside the tetrahedrons covered with plastic, the shoes emitted interesting, milticoloured scenographic light effects through the milky plastic. This accentuated the theme of plastic as necessity, its usefulness and ironic 'beauty'.

Analysis of Practice

- *CEF P3* as part of a gesamtkunstwerk affords:

[212] This is a metaphor we used to embody the feeling our bodies made up of small data bits and bytes that were no longer interconnected, rendering our whole bodies functionless, performing extra normal motions.

    - unique playing styles of the feet
    - affects on-stage architectural and spatial elements (set design)
    - bespoke set-design
    - opportunities for using props in tandem with shoes for actuation.
    - interconnectedness between costumes, props, sounds and scenographic elements
    - aesthetic and material direction for upper body costume.
    - light design of scene through the 'luminance' and 'illuminance' of shoes
    - opportunities to affect dramaturgy and conceptual frameworks of a scene (building up from the shoes).
- *CEF P3* performed with specific pop songs *My Mind is like a Plastic Bag* and *We are Data Remix* surprised audiences.
- Upper body focus in pop performance is changed to audience focussing on the feet.
- Successful coupling of a high-heeled shoe/foot apparatus with a computer to change what we can do with our feet in a performance
- Performer's foot movements are transformed and amplified by the aesthetic possibilities of digital processing.
- Feet and shoes as theatrical light and sound source.
- Support improvisational interaction moving in a light-sounding foot costume in a completely new way, extending the visual costume into the medium of audible and sensory perception and tangible materials in architectural space.

Overall, the *CEF P3* prototype was at the core of the performance, acting as a communication device, furthering a dialogue throughout a range of mediums, each interconnected and informing the other media. Thus, creating a dramaturgy and larger gesamtkunstwerk.

Through the shoes were provided with a 'voice' of their own and formed the base of a musical composition, the sounds produced were still a sequenced beat. This is something that is usually played by the hands via a drum sticks or buttons on a sequencer. I was not totally convinced this system was a better expression than *CEF P1* for the underlying concepts of the *computer enhanced footwear* project.

Figure 122. Performing *Kick-backs* with *CEF P3*, Ars Electronica Festival, Linz, September 2017.

The objectives of the project were to find a language of the feet in a new musical instrument which affords different kinds of unique artistic foot performance and artistic opportunities. This foot system mimicked what the hands usually do in a repeatable, predictable way (always being on the beat and 4/4), though they did lead to several unexpected artistic opportunities.

Figure 123. *CEF P3* shot on location Ars Electronica Festival, Linz, September 2017.

4.5 Conclusion

In this chapter I have described the four main foot-based audiovisual prototype instruments that were developed in collaboration with technologist Sam Ferguson and other collaborating SMEs. I have also presented the primary artistic projects and opportunities that evolved out of prototyping the prototypes in different contexts. I demonstrated how the underpinning theoretical methodologies have been applied to develop the design techniques used in this research. I have also shown how anthropological and philosophical writings, technical designs and artworks using shoes can generate meaning and symbolism in the form of the foot-based musical instruments.

I have also outlined how foot-based musical instruments are communication devices. Like props in a theatrical setting, they can further a dialogue through various mediums and modes including musical sound, fashionable foot costume, playing style and choreography. Even the conception and invention of their new material composition can be communicative. These musical instruments can also have semantic values, as described in Chapter 2, being able to transmit deeper meanings and embody social political discourses through the object. Also, just as is the case with prop design, when designing a musical instrument, consideration should be taken with regards to its visual appearance. Attention to aesthetic materials and visual presentation adds to the expressivity of the instrument, while also contributing to their status as a new and novel invention for the feet.

To help answer the research questions and tackle the prototyping challenges I faced throughout the research project, I devised a *Personal Artistic Method.* This was defined in the chapter and illustrated through the various prototype workshop and performance project accounts supported by online videos and lens-based works. Finally, characteristics of the foot-based instruments were compared and contrasted and related back to the background literature.

Through reflecting on the case study project processes and outcomes, the following new understandings and insights were gained.

- The expression of the shoes is mediated by technology:
  - Through applications of technology, the shoe takes on agency, to become a 'speaking' foot costume with its very own language. The shoe instrument successfully leaves an indelible mark on the whole performance.

    - Digital technology attached to shoes amplifies natural movements, but also makes them seem unusual (there is usually no sound when feet and shoes move in the air).
- Foot-apparatus supports improvisation and interaction:
    - Wearing and performing with the new instrument, facilitates new types of movement, including a new taxonomy of gestures. The new movements were also informed by each performance context and setting.
    - Possibilities are extended when expanding a visual costume into sonic and musical realms.
    - New types of musical improvisation and spontaneity is achieved on stage when using the feet and embedded technology to create sounds and music.
- The physical qualities of *CEF* also inform the aesthetic and material direction that the upper body costume take in performances.
- *CEF* helps to move focus from the upper body to the feet during performance.
- *CEF* liberates the feet, expanding the range of what they could do through a combination of the high heel, technology and theatrical audio visual performance.
- Prototypes are communication devices, which further a dialogue throughout a range of mediums.
- Shoe devices make most sense on stage when they were performed in connection with a single theme, pop song or live composition.
- The shoes influence the dramaturgy of the whole live performance. Designing around the shoes make them a spectacle within the larger gesamtkunstwerk.
- The Shoes surprise and 'affect' audiences:
    - Complex inter-relational aspects and prop nature carries expression to evoke feelings and ideas to 'affect' the viewer
    - They act like a costume seen for the first time. The surprise is sustained longer as the shoes have unseen functions and qualities.
    - Using a recognisable high-heeled shoe embedded with visible circuits and sensors subverts everyday objects inspires an audience to make new associations, which can communicate complex ideas fast.
    - The shoes inform 'never-before-seen' engaging choreographies that showcase the foot.

- The Shoes are a new kind of kinaesthetic technology, they:
    - make me use my feet in a different way
    - create a different human-sensed experience that is embodied, tactile and kinaesthetic.

Drawing from the practice I undertook in this thesis, I have developed the below set of interconnected questions . I term this a **Framework for designing audiovisual foot-based instruments**. These questions are what I consider when making the type of new foot apparatus audiovisual instruments outlined in this case study chapter. I have shared them here in the hope that they will be useful for others making similar work.

Before one begins, consider the connections. Think about the cross-disciplinary approach at all steps of the process and ask yourself, "How could this prototype…"

I. be used to make a foot costume to make sound?
II. consider interactive functionalities, "composition, performance and physical form" as part of the design process (Murray-Brown et al. 2011)?
III. be used on stage working together with a song of three minutes?
IV. be played in several different ways? so each performance of the foot-wearable could be different for each concert or new context. Considering social media and performing so often, one needs to think about how it will be captured and disseminated, so having several different playing styles for an instrument at each performance makes the instrument and overall performance retain its uniqueness each time its seen online or performed live. Eg. the high-heeled shoe guitar is quite cult by now and people expect to see it, so thinking of new ways to perform with it is important, an example of this could be the recent concert at Volksbuhne, where the shoe becomes a dangling shoe at the end of the pink guitar lead.
V. be played collaboratively furthering improvisational interaction with other performers?
VI. create an audiovisual spectacle on stage with the feet, like a guitar solo?
VII. inspire unique playing gestures?
VIII. be used in sounding choreography?

IX. redefine something readymade? e.g. taking an identifiable ready-made high-heeled shoes and changing its meaning and purpose.

X. be seen simultaneously as a fashion statement and a critical costume?

XI. use a costume in a completely new way? e.g. extending a visual costume into the medium of audible sensory perception.

XII. affect dramaturgy and the whole show or direction the artwork takes?

XIII. be used in a gesamtkunstwerk?

XIV. be used in different contexts? e.g. scientific laboratories, fabrication workshops, art and science institutes, art biennales, museums, theatres, music festivals.

XV. be used in conjunction with other available objects? e.g. practical equipment, furniture or props that just happen to be where you are at the time.

XVI. be communication devices to deliver socio-political messages?

XVII. be a prototype of invention and yet simultaneously be accepted as a finished product, piece of art or a one-off pair of shoes someone might want to buy?

XVIII. be shaped by its material instead of being shaped by a pre-prescribed technological process of controlled and predictable computer aided design and manufacturing?

XIX. making process be documented and then integrated in other aspects of the performance or in other contexts? e.g. presentations and exhibitions.

XX. material be engaging and/or ever-changing? e.g. integrating expressive lighting effects, so the audience can see it and it can change visually.

XXI. embed technology in a way that works visually with the conceptual philosophical aims of the prototype and costumes?

XXII. use methods of de-making and/or making strange?

XXIII. be a subversive act or 'break the rules' form of making? e.g. misusing 3D printing technology to create spontaneous and imperfect prints so brokenness becomes embedded in the materiality (Latour 1987; Pinch 1986).

Overall, the *CEF* prototypes discussed in this chapter have facilitated artistic expression in various contexts including theatrical settings, fabrication and scientific laboratories leading to many expected and unexpected artistic outcomes. They have also led to many exciting collaborations during the research process, many of which I could not mention in this thesis, as they were too extensive and complex to explain. Some of these collaborations led me to take decisions regarding the path to take with my future work with *CEF*, which I will describe in the next chapter.

Chapter 5:

Future Artistic Research

5.1 Introduction

In this chapter I present new ideas and design techniques for future iterations of the *Computer Enhanced Footwear* (CEF) prototypes and systems for intended use in a new natural element—water. I will also describe the process of developing a new prototype, a *Computer Enhanced Foot Sock* (CEFS) that features toe stretch sensors for somatic practices, and which, in the future, could serve as a new foot therapy device or costume for performers, dancers and synchronised swimmers.

As part of these future-driven endeavours, I will consider the following:

How can we use the latest in material research to prototype biodegradable 3D print materials to make CEF and CEFS?

What are the considerations of prototyping underwater musical instruments for the feet? What are the requirements of synchronised swimmers?

How can we utilise the rhythmic gestures of synchronised swimmers to create a collective multi-performer foot-based instrument?

How can we use the latest sensor technology coupled with the foot to develop an audiovisual foot sock and associated language of the foot?

5.2 Currents: Underwater directions for CEF

Seeing the colour effects of *CEF P3* emitting through a plastic sheet at the Ars Electronica performance (see section 4.4.4.6), formed a striking scenographic element for the show. As a result, I was convinced the next element for performing *CEF* would be the natural medium of water.

I was interested to see how the light of the submerged *CEF* would refract in water. I also had the assumption that water would be a good element to work in, because of the positive experiences I had working in the foot-liberated space of air. As I described in the case studies chapter, I found *CEF* movements and sounds were best practiced in aerial mode, due to the large range of motions available to the legs and feet. Plus performing in the air did not put a strain on the rest of the body. Therefore, like air, water could facilitate a truly freeing range for leg and feet movement (a liberation of the feet).

I decided to carry out an experimental water movement session in a secret natural cave, located in the side of a cliff, north of Costa Brava, Spain. I captured the experiment using a standard film camera and GoPro underwater camera, and then used the footage to create a short film entitled, *Dive*. Overall, I wanted the scene to be abstract somehow and not clear where it was for the viewer, so this cave presented an interesting unknown element. I was also curious in exploring swimming pools, but for now, the juxtaposition of a natural body of water against technology on the body seemed a more interesting avenue to explore.

First underwater experiments. *Dive,* short film (no sound), 2017

https://vimeo.com/murrayleslie/cefp3filmdive

Figure 124. Still from *Dive,* short film, 2017.

As discussed in section 4.4.2.10, Lonce introduced the idea of having a localised sound in the CEF. Interestingly, early on with *CEF P1* I did briefly explore the idea of integrated speakers with Sam. However, what I have predominately done up to date with the *CEF*, is run the sounds via a PA, very far away from the actual actuation of the shoes.

Figure 125. Still from *Dive,* short film, 2017.

In the future, I plan to integrate a mini PA into the foot appendage, together with its circuits, sensors and batteries. It will be interesting to hear how this sounds underwater and how it can affect the performance.

5.3 Computer Enhanced Foot Sock CEFS

5.3.1 Stretch sensors for the toes

Contemplating iterative design decisions to foster further experimentation and artistic expressivity of the toes visually and acoustically, I reflected on insights gained from the previous actions with the *CEF* prototypes. Thinking back to Marla pole dancing (see section 4.4.2.10) and Krõõt performing on the white museum pedestal during the Lagerfeld performance (see section 4.4.2.12), it dawned on me that toes had the potential of performing as expressive actuators.

The deconstructed design of *CEF P2, a* shoe sole without a shoe upper (see section 4.4.3.1), afforded the free movement of the toes backwards and forwards. This possibility of free toe motion led me to think about coupling the toe flexion with stretch sensors to actuate sound with the future objective to build an expressive foot sock.

I brokered a partnership with the start-up Stretchsense[214] in Auckland, who supported my experimental project by providing custom-made stretch sensors for the toes (they usually design sensors for the hands). Sam and I interfaced the StretchSense sensors together with machine learning software Wekinator (Fiebrink 2010) in combination with Reactor software (see first experiment with stretch toe sensors: https://vimeo.com/murrayleslie/cefp2toe sensors).

The stretch sensors provided precise information about how the toes were moving, with good repeatability. The position data captured fractions of a millimetre and the silicone sensing elements effectively reverted to their original shape when relaxed. The sensors also adequately captured the linear measurements of toe flexion, that is, all toes flexing at once in the same direction. I termed this toe taxonomy 'toe curling'.

Using 'toe curling' as a training model with Wekinator, we coupled it with Reaktor's Skrewell sound generator, which produced a random unrepeatable mix of high frequency FM sound synthesis modulation sounds mixed with static noise (see video link above). The sounds mirrored the concept of the movement of the toes as unrepeatable and messy, unlike the fine dexterity and repeatability of hands (see discussion in section 2.2).

I also did several workshopping sessions together with Rebecca Fiebrink the inventor of Wekinator. In these sessions, we worked on using the stretch sensors actuating different sounds along a timeline, meaning the sounds actuated would change after a period of around 10 seconds. This informed a dynamic way of performing the feet, with an element of surprise, as one did not know what sounds would come next in the randomised timeline of sonic events. In my future research, I intend to continue this work using the timeline in connection with FM sound synthesis in Max/MSP in connection to Wekinator and diverse sound engines.

Simultaneous to testing direct mappings of the toes to various sound engines, I also worked on a physical foot prototype to attach them to. *Plantar fasciitis socks* (compression foot

[214] See https://www.stretchsense.com/.

sleeves with ankle and arch support and additional skeletal toe elements), provided sufficient support for tensing the stretch sensors (see Figure 126. bottom left). Using the compression sock proved to be reliable as far as holding the stretch sensors in place, but disastrous for longer use as the foot started to hurt due to a lack of circulation. Plus, it looked cumbersome and ugly. So, I reverted to using medical tape to connect the sensors to the toes (see Figure 126. top right).

Figure 126. Iterations of attaching toe sensors to the feet. Top left: mock ups with kinesio tape. Top right: medical tape and StretchSense sensors. Bottom left: plantar fasciitis compression foot sock, medical tape and StretchSense sensors. Bottom right: Stretchsense sensors attached to the toes with medical tape.

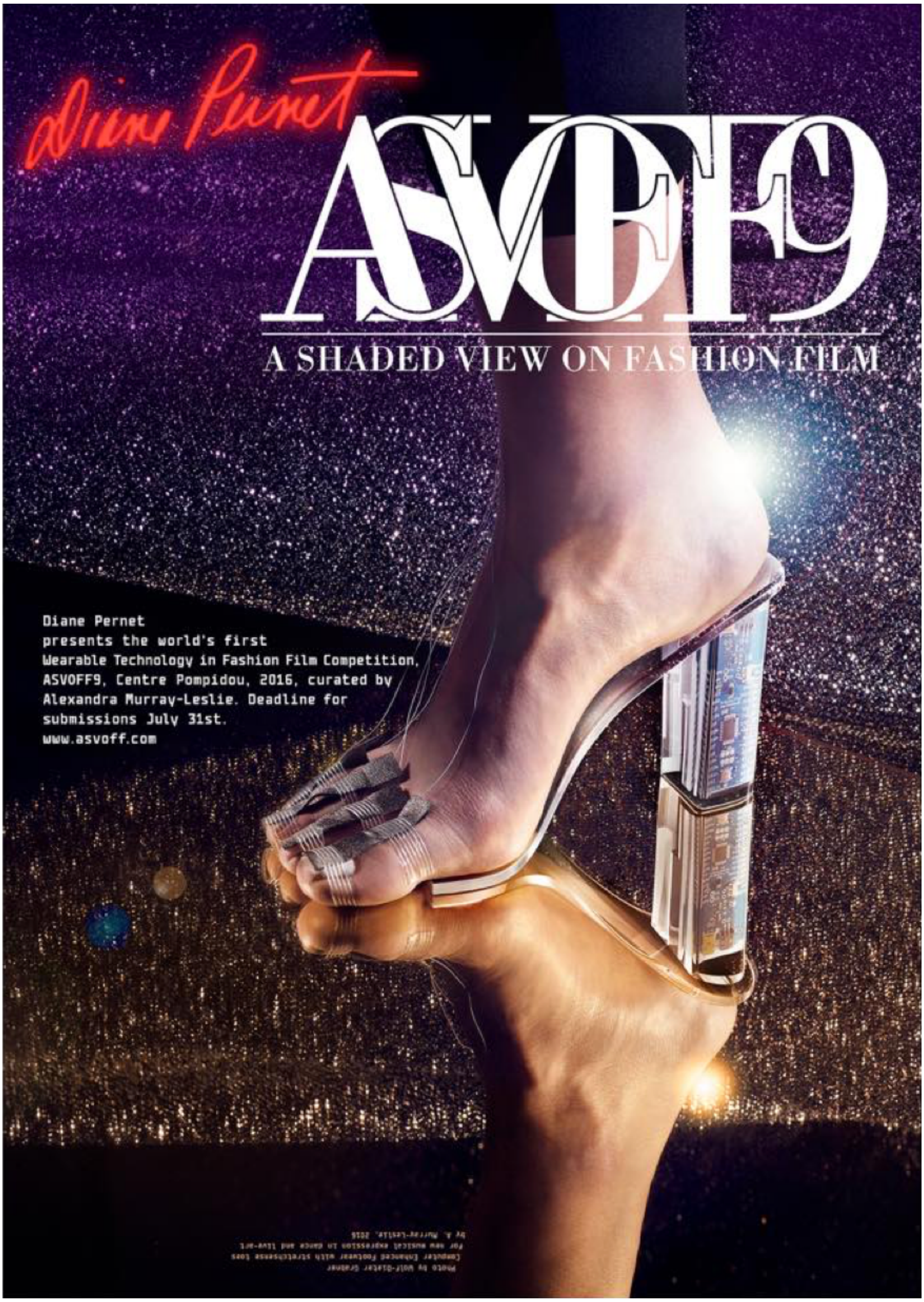

Figure 127. *CEF P2* with added toe stretch sensors as prop on official poster for *A Shaded View on Fashion Film* **(ASVOFF 9), wearable technology competition, 2017[215].**

[215] The poster was featured on leading wearable technology blogs and in fashion media. See: http://electricrunway.com/event/shaded-view-fashion-film-asvoff/.

Using the medical tape had a temporary aesthetic, which was fast and in line with the kinesio tape I had used on the previous experiments. Such a temporary appendage afforded a lighter, free movement of the feet and toes without feeling restricted like with a shoe or the compression foot sock. This approach also ended up being used for a poster to communicate the world's first wearable technology in fashion film competition, *A Shaded View on Fashion Film* (*ASVOFF9*) in 2017 (see Figure 127.).

This direction of using stretch sensors on the toes to map movements and generate sounds is something that I am interested in pursuing further in collaboration with Sam. I also intend to apply this technology and learnings into the development of a new *CEFS* for use on land, air and water.

5.3.2 Prototyping the CEFS

In this section, I will describe my initial experiments with prototyping a foot sock, which I plan to continue developing in future iterations.

Figure 128. 3D scanning the feet

A key challenge of creating a foot sock prototype is ensuring that it is flexible and strong enough to withhold the tensions of feet and toes pulling in different directions. I began to tackle this issue through experimentations with foot scanning (see Figure 128.) to create detailed 3D mesh models of the feet. I then used Autodesk Fusion 360 software to refine the mesh. Using the program, I added t-splines to create a web-like structure around the foot which could then be filled in, creating a foot sock (see Figure 129.)

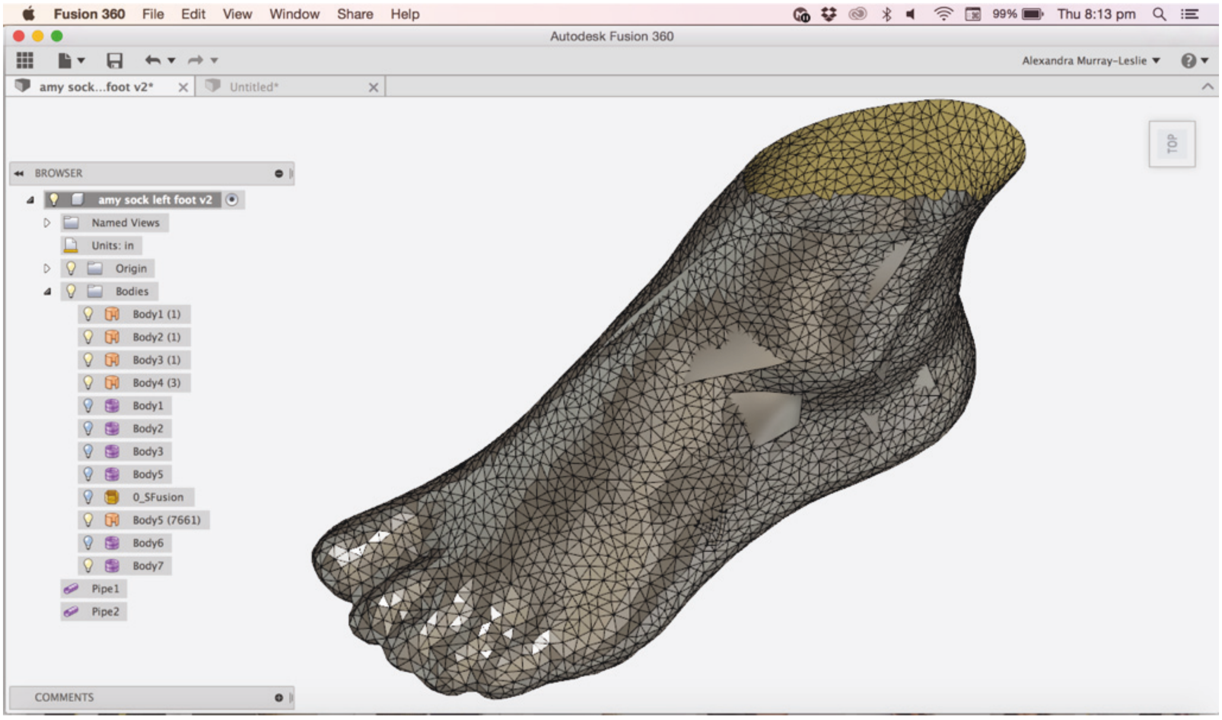

Figure 129. 3D scan of feet transformed into triangular mesh (with closed t-spline sections) in Fusion 360, Autodesk, Pier 9 Technology Centre, San Francisco, 2016.

After several hours of exploration on-screen, I became frustrated at the slow, non-physical way of working and opted to do a fast and dirty prototype instead. I decided that a handmade version using tangible materials would quickly give me the answers I was looking for. This faster approach would help me to confirm whether this direction of pursuing the making a foot sock with integrated stretch sensors made sense. Through some insightful discussions with artist-in-residence colleagues at Pier 9, I decided to try using silicone directly on the skin with embedded stretch toe sensors.

To do this, I invited artist Amy Karle to collaborate with me, as I wanted to work with a peer artist resident as a way to drive the experiments in unexpected directions and go outside my comfort zone. I was also interested in documenting[218] the making stages to see what other artistic outcomes of the feet could arise. I used an orbiting time lapse rig[219] that was invented by my peer resident McIndoe (aka Makendo) to capture the multiple view points of the process.

Figure 130. Silicone foot sock with embedded copper strips (to emulate the toe stretch sensors).

Overall, I found the silicone material too messy and unreliable, as it tore when the sock was put on and off the foot. While I did not find it to be convincing during these tests, it is still something I would like to pursue further in the future. However, the documentary process of the silicone tests did produce some interesting artistic outcomes including lens-based works (see Figure 130.) and two videos:

- a foot sock-making scene with Amy: https://vimeo.com/283154832 (see Figure 131.)
- Amy performing the foot sock https://vimeo.com/283154338.

[218] Documenting work processes was thoroughly encouraged at Autodesk, Pier 9, as was publishing on their online platform, Instructables, https://www.instructables.com/.
[219] See: https://www.instructables.com/id/Orbiting-Time-Lapse-Rig/.

These documentary videos went on to be incorporated into the *We are Data Remix* music video (as documented in Chapter 4. Case Studies).

Figure 131. Still from video of Amy Karle and I performing the foot sock while embodying the slogan *meet your feet*, Autodesk, Pier 9 Technology Centre, San Francisco, 2016.

5.4 Future Wet Feet

Building upon the initial sensor tests and prototyping experiments, my hope is that in the future, I will produce a new *CEF P4* prototype that can function underwater and add new possibilities to water performances, such as synchronised swimming. I am also interested in exploring the *CEFS* as its own device. I think it could have interesting uses on land and in air in somatic practices and sound therapy, additional future contextual scenarios to explore.

I aim to produce a wearable foot and toe encased device, where the circuit, sensors and battery are situated just under the arch of the foot, so as not to impede movements in the water.

The 3D design will be developed through a series of semi-structured interviews with swimmers, forming understandings of their needs. I will also work closely with expert synchronised swimmers at CAR Barcelona and other Olympic synchronised swimmers in Auckland and the US. (Which is very different to my previous experiences working with performers and artists on stage). These understandings will be coupled with the restraints of working with electronics in the water, with the objective to make a functional, water-proof, musical foot-based prototype.

In conjunction with the underwater prototype development, I also hope to continue working with the stretch sensors and other technologies inside the *CEFS*. The first prototypes will use both the *CEF P1* circuit and system and *CEF P3* Protopixel lighting system for initial testing. After the design of a successful encasing for these circuits is iterated and integrated in a prototype that is comfortable for underwater dancers, my objective is to merge the elements to create a new technical system to form a self-contained musical instrument foot-apparatus. Unlike the research in this thesis, which was about separating the interface from the sound-producing medium, this new *CEF P4* considers different states of matter, both the user-interface and the sound production medium (Mann 2007). This new system will be capable of achieving freestyle polyphonic modular FM sound synthesis (with effects), together with rhythmic patterns and lighting effects. For this stage of the development (and future iterations) I will continue my collaboration with Sam and Protopixel engineers

I also foresee the need for more ArtScience collaborations. In the near future, this will begin at Norwegian University of Science and Technology with Martin Steinert[223] for specific convergent problem solving of engineering and design aspects. I will also collaborate with Steve Mann who has pioneered theories and practices around fluid musical instrument design and natural user interfaces.

Overall, this future project will aim to bring together the divergent practices of art and sport in the context of audiovisual theatrical water performance.

[223] https://www.ntnu.edu/employees/martin.steinert.

5.5 Conclusion

This chapter has described potential scenarios for developing new *CEF* prototypes for audiovisual theatrical performance. I have presented initial work I have already embarked on to test underwater functionality and develop toe stretch sensors using my personal artistic method and framework. Through these accounts of my initial experiments, I also featured artistic photography and video works that came about through the documentation process.

These early experiments illustrate my continued efforts to take my work in new directions —to learn, create and experiment inside a larger gesamtkunstwerk. To realise my hopes of create foot-based instruments that embrace performance of the air, earth and water and which liberate the feet.

Chapter 6: Conclusion

6.1 Conclusion

In this thesis, I have presented the iterative design and development of four foot-based audiovisual instruments for theatrical musical performances inside a larger gesamtkunstwerk frame. The work has emerged from my artistic practice both as a performance artist, musician, 3D designer and fabricator working within transversal contexts.

I have provided a brief history of my practice and the early versions of the shoe instruments and other objectinstruments that I had created with Melissa Logan, co-founder of Chicks on Speed, before the research was formalised. I also elaborated on concepts and histories about feet and shoes derived from a rich body of literature from a range of disciplines, including anthropology, natural history, medicine, performance art, pop music, prosthetics, shoe fashions and inventions and new musical instrument design.

I described how I used my self-reflective, practice-based artistic method to develop the foot-based instruments and help answer the research questions. In addition, I included several videos and lens-based works to help communicate the audiovisual qualities and contexts of prototyping and performing with the *Computer Enhanced Footwear* (*CEF*) during various collaborative projects.

Through a series of case studies, I presented insights into the process of iterative prototyping and performing with *CEF P1-3* prototypes inside my artistic practice along with the unexpected outcomes and opportunities that arrised when working in these contexts. The sometimes spontaneous and improvised performances during and after prototyping processes took place at sports science labs, fabrication workshops, pole dance studios, fashion catwalks museums, music and art festivals, and at times even generated out of moments of jumping around on road cases and guitar amps.

The main contribution of this written thesis came from reflection on finalising the case studies chapter where I concluded by suggesting some effective ways of prototyping new types of semantic foot based digital musical instruments.

Arising from the process of documenting, collating and reflecting upon my body of work undertaken for this thesis, I have developed a **Framework for designing audiovisual foot-based instruments**. This framework, which is made up of interconnected questions, is a key outcome of the research, based on many years of artistic practice—an outcome I hope will be useful for others undertaking similar work.

Before one begins, consider the connections. Think about the cross-disciplinary approach at all steps of the process and ask yourself, "How could this prototype…"

I. be used to make a foot costume to make sound?
II. consider interactive functionalities, "composition, performance and physical form" as part of the design process (Murray-Brown et al. 2011)?
III. be used on stage working together with a song of three minutes?
IV. be played in several different ways? so each performance of the foot-wearable could be different for each concert or new context. Considering social media and performing so often, one needs to think about how it will be captured and disseminated, so having several different playing styles for an instrument at each performance makes the instrument and overall performance retain its uniqueness each time its seen online or performed live. Eg. the high-heeled shoe guitar is quite cult by now and people expect to see it, so thinking of new ways to perform with it is important, an example of this could be the recent concert at Volksbuhne, where the shoe becomes a dangling shoe at the end of the pink guitar lead.
V. be played collaboratively furthering improvisational interaction with other performers?
VI. create an audiovisual spectacle on stage with the feet, like a guitar solo?
VII. inspire unique playing gestures?
VIII. be used in sounding choreography?
IX. redefine something readymade? e.g. taking an identifiable ready-made high-heeled shoes and changing its meaning and purpose.
X. be seen simultaneously as a fashion statement and a critical costume?
XI. use a costume in a completely new way? e.g. extending a visual costume into the medium of audible sensory perception.
XII. affect dramaturgy and the whole show or direction the artwork takes?
XIII. be used in a gesamtkunstwerk?

XIV. be used in different contexts? e.g. scientific laboratories, fabrication workshops, art and science institutes, art biennales, museums, theatres, music festivals.

XV. be used in conjunction with other available objects? e.g. practical equipment, furniture or props that just happen to be where you are at the time.

XVI. be communication devices to deliver socio-political messages?

XVII. be a prototype of invention and yet simultaneously be accepted as a finished product, piece of art or a one-off pair of shoes someone might want to buy?

XVIII. be shaped by its material instead of being shaped by a pre-prescribed technological process of controlled and predictable computer aided design and manufacturing?

XIX. making process be documented and then integrated in other aspects of the performance or in other contexts? e.g. presentations and exhibitions.

XX. material be engaging and/or ever-changing? e.g. integrating expressive lighting effects, so the audience can see it and it can change visually.

XXI. embed technology in a way that works visually with the conceptual philosophical aims of the prototype and costumes?

XXII. use methods of de-making and/or making strange?

XXIII. be a subversive act or 'break the rules' form of making? e.g. misusing 3D printing technology to create spontaneous and imperfect prints so brokenness becomes embedded in the materiality (Latour 1987; Pinch 1986).

Finally, within this thesis, I have also outlined future prototyping work that has emerged from working with the *CEF* using my *personal artistic method* and frame work. This includes future collaborations to create new foot-based audiovisual instruments that will lead me from air and earthbound explorations to water-based, theatrical endeavours with scientists and synchronised swimmers.

Overall, I hope that this research has communicated the energy of making and infinite possibilities of working within a gesamtkunstwerk frame to embrace interconnected explorations of art, performance, music, technology, sport and science. As well as show that it is possible to ideate and make new digital musical instruments with semantic qualities to expand perceptions and understandings of the human feet.

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Appendix A

List of public events with *Pre-prototype, CEF P1, CEF P2* and *CEF P3*

Below is a thorough list of all the public performances, film festivals, conferences and exhibitions with *Computer Enhanced Footwear* prototypes: *Pre-prototype, CEF P1, CEF P2, CEF P3, E-Shoe, E-Shoe iPad App* and *A High Heeled Shoe Guitar*. The date, event name, location and performers. Where available, a link to documentation, videos and/or selected media about the event is included.

17-20/01/2013

Museum of Old and New Art, Tasmania, AU
MOFO Festival
Performance, artist in residence and keynote presentation by Chicks on Speed
(*Pre-prototype*, *CEF P1* and *High Heeled Shoe Guitar*)

13/03-21/04/2013

Artspace, Sydney, AU
Scream
Exhibition by Chicks on Speed
(*E-Shoe*, *E-Shoe iPad App* and *Pre-prototype*)

Media:
Artand, Vol 50 Number 3 Autumn 2013

http://www.undertheradar.co.nz/tour/2559/Chicks-On-Speed.utr

7/05/2013 **55th Venice Biennale, IT**

Australian Pavilion Vernissage

Performance by Chicks on Speed

(*CEF P1*)

27/07-02/08/2013 **Paillard Centre d'Art Contemporain & Résidence d'Artistes, Poncé sur le Loir, FR**

E-textile Summer Camp

Presentation

(*Pre-prototype* and *E-Shoe*)

03/08-21/09/2013 **Institute of Modern Art, Brisbane, AU**

Scream

Exhibition by Chicks on Speed

(*E-Shoe* and *E-Shoe iPad App*)

Media:

http://www.art-almanac.com.au/chicks-on-speed-scream/

https://news.artnet.com/exhibitions/julian-assange-guest-stars-on-chicks-on-speeds-artstravaganza-50890

09-12/09/2013 **ETH, Zurich, CH**

The International Symposium on Wearable Computers (ISWC)

Design exhibition

(*CEF P1*)

17/09/2013 **The Drill Hall, Sydney, AU**

SEAM Conference: Authorship, Curation, Audience

Prototype Hits

Performance

(*Pre-prototype*)

Video:

https://vimeo.com/244956351/53d06dab4eh

30/11/2013 **ZKM, Centre for Art and Media, Karlsruhe, DE**

Giga-Hertz Prize Festival

Performance by Chicks on Speed

(*CEF P1*)

13/12/2013-08/03/2014 **RMIT Design Hub, Melbourne, AU**

Scream

Exhibition by Chicks on Speed

(*E-Shoe* and *E-Shoe iPad App*)

28/02/2014 **Museum of Contemporary Art Australia, AU**

Performance by Chicks on Speed

(*Pre-Prototype*)

Video:

https://vimeo.com/murrayleslie/preprototype-museum-of-contemporary-art-australia

01/03/2014 **Queensland University of Technology, Brisbane, AU**

Xcommunicate: EMARE (European Media Artists in Residence Exchange) Symposium

Keynote presentation

(*Pre-prototype* and *CEF P1*)

02/03-21/04/2014 **City Gallery, Wellington, NZ**

Touch me baby, I'm bodycentric, a multimodalplosion

Exhibition by Chicks on Speed and Lisa Walker

(*Pre-prototype*)

17/03-25/05/2014

Whitney Biennial, New York, US

Film by Chicks on Speed in collaboration with A.L. Steiner

(*Pre-Prototype*)

04/04-25/05/2014

Fremantle Arts Centre, Perth, AU

Scream

Exhibition by Chicks on Speed

(*E-Shoe*, *E-Shoe iPad App* and *CEF P1*)

30/06/2014

Goldsmiths, University of London, UK

New Interfaces for Musical Expression, Practice-based Research Workshop

Paper presentation

Publication:

https://www.creativityandcognition.com/NIMEWorkshop/wp-content/uploads/2014/06/paper-1.pdf

08-11/10/2014

70th SECAC (Southeastern College Art Conference), Sarasota, Florida, US

Nexus: From Handmade to High-tech

Keynote presentation

(*Pre-prototype* and *CEF P1*)

24/10-08/11/2014

School of Art, Design and Media, Nanyang Technological University, SG

Sense and Sensuality, The Art and Aesthetics or Wearable Technology

Exhibition

(*High Heeled Shoe Guitar* and *CEF P1*)

29/10/2014	**School of Art, Design and Media (ADM), Nanyang Technological University, SG** *Sense and Sensuality, The Art and Aesthetics or Wearable Technology Exhibition, Colloquy: Extending Oneself and One's Community* Keynote presentation (*CEF P1* and *CEF P2*)
06/12/2014	**Radial System, Berlin, DE** *Wir Sind Daten* Performance by Chicks on Speed (*CEF P1* and *High Heeled Shoe Guitar*)
07/12/2014-28/02/2014	**401Contemporary, Berlin, DE** *Datastravaganza* Exhibition by Chicks on Speed (*Pre-Prototype* and *E-Shoe*) Media: https://www.monopol-magazin.de/theorien-tanz-mit-julian-assange
19/12/2014	**Brut Theatre, Vienna, AT** Performance by Chicks on Speed (*CEF P1* and *High Heeled Shoe Guitar*)
04/04-25/05/2014	**Fremantle Art Centre, Perth, AU** *Scream* Exhibition by Chicks on Speed (*Pre-prototype* and *E-Shoe*)

11-12/10/2014	***Wearit* Conference Berlin, DE** Keynote lecture (*Pre-prototype* and *CEF P1*) Video: https://www.youtube.com/watch?v=xY_eGhuJJKs
6/02/2015	**National Gallery of Victoria, AU** *The Fashion World of Jean Paul Gaultier: From the Sidewalk to the Catwalk* Performance by Chicks on Speed (*CEF P1* and *High Heeled Shoe Guitar*) Media: http://themusic.com.au/music/livereviews/2015/02/09/chicks-on-speed-ngv-guido-farnell/
13/02-01/03/2015	**Milani Gallery, Brisbane, AU** *Golden Gang* Exhibition by Chicks on Speed (*Pre-prototype*, *CEF P1* and *High Heeled Shoe Guitar*)
17/03/2015	**The University of Sydney, AU** **University Art Gallery and the Philosophy Room, The Quadrangle and Verge Gallery** *Girls at the Tin Sheds: Sydney Feminist Posters 1975-90* Film screening (*Pre-prototype*)
16-19/04/2015	**Art Cologne, DE** Exhibition by Chicks on Speed (*Pre-prototype* and *E-Shoe*)

Media:

https://www.theguardian.com/music/2015/jun/14/isle-of-wight-festival-2015-review

11/05-29/05/2015 **RMIT Design Hub, Melbourne, AU**

Experimental Practice: Provocations in Design

Exhibition

(*CEF P1*)

18/05/2015 **56th Venice Biennale, IT**

The University of the Arts Helsinki, Research Pavilion, *Experimentality* (a collaboration with Frame Visual Art Finland and the Alvar Aalto Pavilion of Finland)

Performance by Chicks on Speed

(*CEF P1*)

Video:

https://www.facebook.com/alexmurrayleslie/videos/10153278795022154/

Catalogue:

https://www.uniarts.fi/sites/default/files/CATALOGUE_1st_Research_Pavilion_Venice_2015_0.pdf

29/05/2015 **NTU, Centre for Contemporary Art Singapore, SG**

The Art of Work

Performance by Chicks on Speed

(*CEF P1*)

Video:

https://vimeo.com/murrayleslie/cefp3chicksonspeedtheartofwork

Media:

https://www.cobosocial.com/art-and-design/chicks-on-speed-in-singapore-to-redefine-the-art-of-working-it/h

http://ashadedviewonfashion.com/2015/07/31/footwerk-sounding-foot-wearables-performance-alexandra-murray-leslie-collaboration-singapore/

30/05-07/06/2015 **Art Science Museum, SG**

Scream

Exhibition by Chicks on Speed

The Art of Work Part 2

Performance by Chicks on Speed

(*CEF P1*)

14/06/2015 **Isle of Wight Music Festival, UK**

Performance by Chicks on Speed

(*CEF P1*)

17/06/2015 **Sónar+D, Innovation Challenge, Barcelona, ES**

Keynote presentation

(*CEF P1* and *CEF P2*)

26/06/2015 **Donauinselfest, Vienna**

Performance by Chicks on Speed

(*CEF P1*)

25/07/2015 **NTU, Centre for Contemporary Art, SGP**

Art day Out

Performance by Alexandra Murray-Leslie and Marla Bendini

(*CEF P1*)

12/09/2015	**Bundeskunsthalle Bonn, DE**

Karl Lagerfeld Modemethode

Artstravaganza

Performance by Chicks on Speed

Video:

https://vimeo.com/murrayleslie/footwerk-lagerfeld-bundeskunsthalle

Media:

http://www.vogue.it/en/vogue-talents/video-lab/2016/03/04/atstravaganza-chicks-on-speed/

http://dresscodehighfashion.blogspot.co.nz/2015/09/chicks-on-speed-artstravaganza-at-karl.html

http://ashadedviewonfashion.com/2015/11/01/chicks-speeds-founding-members-alex-murray-leslie-and-melissa-logan-presented-artstravaganza/h

http://www.sidf.eu/MUSIC/Chicks-on-Speed

18/09-07/11/2015	**Griffith University Art Gallery, AU**

Experimental Thinking, Design Practices

FOOTwerk, Improvisations in Gender, Sound and Space

Exhibition

(CEF P1)

Book:

https://issuu.com/qcagriffith/docs/experimental_thinking_design_practi

31/10/2015 **Gallery of Modern Art, Brisbane, AU**

Future Beauty

Performance

(*CEF P1*)

26/11/2015 **Design Friends, Rotondes, LX**

High Techne Fashion: Computer Enhanced Footwear for the Audiovisual Aestheticisation of the Human Body (from Chicks on Speed to Academia)

Keynote performance

(*CEF P1*, *CEF P2*, *High Heeled Shoe Guitar* and *E-Shoe*)

Online and printed book publication:

https://issuu.com/designfriends/docs/alexandra_murray-leslie

Media:

http://paperjam.lu/news/les-poulettes-de-la-musique

06-08/11/15 **Zürich University of the Arts, CH**

Shoes Designer Product, Everyday Object, Research Topic

Keynote presentation

(*Pre-prototype* and *CEF P1*)

09/12/15 **Earsthetic Festival, Brighton, UK**

Performance by Chicks on Speed

(*CEF P1*)

18/12/2015 **Centre Pompidou, Paris, FR**

A Shaded View on Fashion Film Festival

Performance by Chicks on Speed

FOOTwerk: Improvisations in Gender, Sound and Space

	Film screening
	(*CEF P1* and *High Heeled Shoe Guitar*)
	Video:
	https://vimeo.com/149429831h
	Media:
	http://ashadedviewonfashion.com/2015/12/18/asvoff-8-chicks-speed-concert/
31/01/2016	**Volksbuhne, Berlin, DE**
	Artstravaganza
	Performance by Chicks on Speed
	(*CEF P1*)
	Video:
	https://vimeo.com/murrayleslie/cefp1chicksonspeedvolksbuhne
10/02/2016	**Atelier Neerlandais, Paris, FR**
	Embracing Fashion and Technology
	Keynote presentation
	(*CEF P2*)
	Media:
	http://ashadedviewonfashion.com/2016/02/10/wednesday-10th-february-13h30-alex-murray-leslie-will-announce-launch-wearable-technology-film/
07/04/2016	**Eurecat, Centro de Investigación y Transferencia de Tecnología Textil en Canet de Mar, ES**
	Innovación, creatividad y talento: descubriendo nuevos lenguajes

Keynote presentation

(*Pre-prototype*, *CEF P1* and *CEF P2*)

19/04-13/04/2016 **Creative Industries Precinct, Queensland University of Technology, AU**

Geek Girls

FOOTwerk; Improvisations in Gender, Sound and Space

Exhibition

(*CEF P1*)

26/04/2016 **Barge House, London, UK**

Death of Fashion? Dialogue, Performance, Discussion, Corporal Breakdown, Fashion Circuits

Performance

(*CEF P1* and *High Heeled Shoe Guitar)*

08/07/2016 **Pohoda Festival, SL**

Performance by Chicks on Speed

Video:

https://www.youtube.com/watch?v=sZlUDKUHpvc

18/07/16 **Department of Computing, Goldsmiths, University of London, UK**

Keynote lecture

(*Pre-prototype*, *CEF P1* and *CEF P2*)

5/10/2016 **Grey Area for the Arts, San Francisco, US**

Keynote presentation

(*CEF P1, CEF P2* and *CEF P3*)

06/10-30/10/2016	**Telstra Perth Fashion Festival, Raine Square, Perth, AU**
	Fashioning Technology
	Exhibition
	(*CEF P1*)
	Catalogue:
	http://telstraperthfashionfestival.com.au/sites/default/files/Fashioning Technology Catalogue.pdfh
25/11/16	**Pier 9, Autodesk, San Francisco, US**
	Keynote presentation
	(*Pre-prototype, CEF P1, CEF P2* and *CEF P3*)
1-4/12/2016	**Pier 9, Autodesk, San Francisco, US**
	Residency Showcase
	Exhibition
	(*CEF P3*)
27/02-02/03/2017	**Youth Mobile, Mobile World Congress, Barcelona, ES**
	ECOcyborg Fashion Tech Show
	Six performances
	(*CEF P3*)
	Television media:
	Flash Moda, Televisión Española, presented by Nieves Álvarez, (00:05:18)
	http://www.rtve.es/alacarta/videos/flash-moda/flash-moda-11-03-17/3940970/
	TV3, Generació Digital, (00:00:21)

http://www.ccma.cat/tv3/alacarta/generacio-digital/generacio-digital-capitol-194-especial-mobile-world-congress/video/5654091/

Antena 3
http://www.antena3.com/noticias/tecnologia/los-ninos-tambien-disfrutan-del-congreso-de-moviles_2017022858b5df180cf2fa92de559703.html

TV3
http://www.ccma.cat/tv3/alacarta/telenoticies-vespre/el-festival-yomo-arrenca-amb-realitat-virtual-robotica-i-impressores-3d/video/5653422/

Info K, Super 3, (00:03:07)
http://www.ccma.cat/tv3/super3/infok/especial-yomo-2017/video/5653443/

Betevé
(00:03:35): https://btv.playty.com/player#/video?autoplay=1&id=227-2121

Informativos noche 8 TV
http://www.8tv.cat/8aldia/8-al-dia-amb-josep-cuni/les-dones-poc-mes-del-20-dels-assistents-al-mobile/
Print media:
Diari Ara
http://www.ara.cat/estils_i_gent/moda-sostenible-tecnologica-del-futur_0_1748825144.html

El Mundo, Innovadores

http://www.elmundo.es/economia/2017/02/14/58a2d83146163fde5a8b458c.html

Online media:

Tendencias.tv

https://tendencias.tv/diary/moda/ecocyborg-yomo/

A Shaded View on Fashion

http://ashadedviewonfashion.com/2017/03/06/ecocyborg-selfiedress-by-saeun-kjartansdottir-alex-murray-leslie/

ELPaís

http://elpais.com/eventos/2017/02/28/mwc/1488294092_925356.html

A shaded View on Fashion

http://ashadedviewonfashion.com/2017/02/27/fashion-tech-show-at-ied-barcelona-starring-the-inventor-of-wearable-technology-steve-mann/

It Fashion

http://www.itfashion.com/moda/moda-y-tecnologia-estrechan-lazos-a-favor-de-la-sostenibilidad/

It Fashion

http://www.itfashion.com/cultura/barcelona/la-moda-en-el-mobile-world-congress/

20,21,22/02/2017 **Silencio, Paris, FR**

Memetic Octopus

Performance art collaboration with ORLAN and Anat Ben-David (*CEF P1* and *High Heeled Shoe Guitar*)

13/05/2017 **Kunsthalle Basel, CH**

Look Therapy, All Over, Over All

(*CEF P1* and *High Heeled Shoe Guitar)*

Videos:

https://www.facebook.com/alexmurrayleslie/videos/10155273149967154/

https://vimeo.com/219075126h

Media:

http://ashadedviewonfashion.com/2017/06/12/look-therapy-avantgardening-demaking-in-havocs-havenly-kingdom/

16/05/2017 **Aalborg University Copenhagen, DK**

New Interfaces for Musical Expression (*NIME*) *conference*

Paper presentation

(*Pre-prototype, CEF P1, CEF P2* and *CEF P3*)

Publication:

http://homes.create.aau.dk/dano/nime17/papers/0057/paper0057.pdf

23/05/2017 **Image Movement Berlin, DE**

MOVES#147 Chicks on Speed present »We Are Data«

Film screening

(*CEF P3*)

09-11/06/2017 **A Shaded View on Fashion Film, Balkan Fashion Week, Nu Boyana Film Studios, BG**

Keynote presentation, film screening and master class

(*CEF P1, CEF P2* and *CEF P3*)

Media:

http://www.clotmag.com/weareable_technologies

http://electricrunway.com/event/shaded-view-fashion-film-asvoff/

09/06-24/09/2017	**Science Gallery Dublin, IE** *Sound Check* Exhibition (*CEF P1* and *High Heeled Shoe Guitar*)
13/06/2017	**Science Gallery Dublin, IE** *Shoe Shredding* Keynote presentation (*Pre-prototype, CEF P1, CEF P2* and *CEF P3*)
15/06/2017	**Science Gallery, Dublin, IE** *Moog Sound Lab Residency* Performance (*CEF P1*)
29/07/2017	**Yo Sissy Music Festival, Berlin, DE** Performance by Chicks on Speed (*CEF P3*)
07/09/2017	**Ars Electronica Festival, Linz, AU** *The Liberation of the Feet: Demaking the High Heeled Shoe for Audiovisual Expressivity* Performance (*CEF P3*) Media: Radio FM 4

http://fm4.orf.at/player/20170909/MO/061719

10/09/2017	**Templehof Airport, Volksbuhne Berlin, DE** *Fous de dance* by Boris Charmatz DJ set performance (*CEF P3*) Media: http://www.die-deutsche-buehne.de/Kritiken/Tanz/Tempelhof+Fous/Prekaerer+Zauberh
14/11/17	**National Institute of Dramatic Art, Sydney, AU** *Costume Research in Australasia Research Seminar* Keynote presentation (*CEF P1, CEF P2* and *CEF P3*)
30/11-1/12/2017	**Whitechapel Gallery, London, UK** *Turning Earths Symposium* *FOOTwerk, Improvisations in Gender, Sound and Space* and *Dive* Film screening (*CEF P1* and *CEF P3*)
11/04/2018	**The University of Plymouth (Devon), UK** *Society for Artistic Research, 9th International Conference on Artistic Research, 'Artistic Research Will Eat Itself'* Performance keynote presentation (*CEF P1, CEF P2, CEF P3* and *High Heeled Shoe Guitar*)
22/04/2018	**Dutch Art Institute, ArtEZ University of the Arts, Planetary Campus, Civic centre, Sant Augusti, Barcelona** *Roaming Assembly #21-Cracking the Mould*

Performance keynote presentation

(*CEF P1*, *CEF P2* and *CEF P3*)

04/05/2018 **Fondazione Fabrica Europa, Florence, I**

Performance by Chicks on Speed

(*CEF P3*)

05/05/2018 **Trondheim Electronica Arts Centre, Trondheim, NO**

Biennale for Contemporary Art, Dangerous Futures Conference,

Performance by Chicks on Speed

Keynote presentation

(*CEF P1* and *CEF P3*)

10/05/2018 **Volksbuhne, Berlin, DE**

20 years Chicks on Speed

Performance by Chicks on Speed

(*CEF P3*)

Media:

https://www.deutschlandfunkkultur.de/20-jahre-chicks-on-speed-a-german-gesamtkunstwerk.2177.de.html?dram:article_id=417577h

https://ashadedviewonfashion.com/2018/05/20/volksbuhne-berlin-chicks-on-speed-celebrate-20-year-anniversary-concert-with-douglas-gordon-peaches-kiki-moorse-and-the-real-housewives-of-neukoeln-photos-by-wolf-dieter-grabner/

https://qetic.jp/?p=290794&preview=1&_ppp=9e9f512685

30/05/2018 **Techniches Museum, Vienna, AU**

Theatre of Making

Performance by Chicks on Speed

	(*CEF P1)*
01/06/2018	**Academy of Arts, Riga, Latvia** *Riga Biennale of Contemporary Art* Performance by Chicks on Speed (*CEF P1 and High Heeled Shoe Guitar)*
21/06/2018	**QCA, Queensland College of Art, Griffith University** *Technology in the Creative arts: panel discussion* Keynote presentation (*CEF P1*, *CEF P2*, *CEF P3*, *EShoe* and *High Heeled Shoe Guitar*)
05/10/2018	**Casino Luxembourg, Forum d'art contemporain, Lux** *10 years Design Friends* Performance (*CEF P1*, *CEF P3* and *High Heeled Shoe Guitar*)
06/09/2018	**Ars Electronica, Linz, AU** *Ars Electronica Festival* Performance by Chicks on Speed (*CEF P1*, *CEF P3* and *High Heeled Shoe Guitar*)
08/09/2018	**Anton Bruckner Private University, Linz, AU** *.. under control of Music | Music under control of .. | Composing (in) digital worlds, Symposium, Sonic Saturday, Ars Electronica Festival* Performance keynote presentation (*CEF P1*, *CEF P2*, *CEF P3*, *EShoe* and *High Heeled Shoe Guitar*)
26/09/2018	**Villa Stuck, Munich, DE** *50 years Villa Stuck* Performance by Chicks on Speed

(*CEF P1*, *CEF P2*, *CEF P3*, *EShoe* and *High Heeled Shoe Guitar*)

09/10/2018	**Jean-Paul Gaultier Foundation Paris**
	A Shaded View on Fashion Film 10
	Performance keynote presentation and *Dive* Film screening
	(*CEF P1* and *CEF P3*)

Appendix B

Associated Publications

Murray-Leslie, A. 2019, ‘Theatrical performances with Objet Connex 500 3d printer; making computer enhanced footwear prototypes’, in C. Schnugg (ed.), *Creating ArtScience Collaboration - Bringing Value to Organizations*, Palgrave Macmillan, London, pp. 130-136.

Murray-Leslie, A. 2019, ‘Deinscribing the high-heeled shoe: Costuming the foot for theatrical audiovisual performance’, in P. McNeil & S. Pantouvaki (eds), *Performance Costume – New Perspectives and Methods*, Bloomsbury, London, pp. 90-95.

Murray-Leslie, A. 2018, ‘I don’t play guitar: performing post-digital high-heeled shoes as musical instruments for the feet’, in G. Stocker, C. Schöpf & H. Leopoldseder (eds), *Ars Electronica Catalogue: Error-The Art of Imperfection*, Hatje Cantz Verlag GmbH, Berlin, pp.

Murray-Leslie, A. & Johnston, A. 2018, ‘The liberation of the feet: De-making the high-heeled shoe for theatrical audio-visual expression’, in U.M. Bauer & A. Rujoiu (eds), *Place. Labour. Capital. The making of an Institution*, NTU Centre for Contemporary Art Singapore, Singapore.

Murray-Leslie, A. 2018, ‘Demaking the high-heeled shoe’, in L. Candy, E. Edmonds & F. Poltronieri (eds), *Explorations in Art and Technology*, Springer Verlag, Berlin.

Murray-Leslie, A. & Johnston, A. 2017, ‘Demaking the high-heeled shoe for theatrical audio-visual expression’, *Proceedings of the International Conference on New Interfaces for Musical Expression*, Aalborg University Copenhagen, Denmark.

Logan, M. & Murray-Leslie, A. 2017, ’99 Cents’, in F. Spampinato (ed.), *Art Record Covers*, Taschen, Cologne, Germany, pp. 103-107.

Murray-Leslie, A. 2017, ‘Demaking the high-heeled shoe, computer enhanced footwear’, *Sound Check*, Science Gallery, Dublin.

Murray-Leslie, A. & Logan, M. 2016, ‘Chicks on Speed’, in F. Spampinato (ed.), *Can you hear me? Music labels by visual artists*, 1st edn, Onomatopee, Eindhoven, pp. 9, 64, 67, 78-79, 100.

Murray-Leslie, A. 2016, ‘Open Source Strides’, in A. Farren & B. Quinn (eds), *Fashioning Technology*, Telstra Perth fashion Festival, Perth.

Murray-Leslie, A. 2015, ‘Alexandra Murray-Leslie (Chicks on Speed)’, T. Grandas, B. Preciado & A. Dressen (eds), *The passion according to Carol Rama*, 1st edn, Barcelona Museum of Contemporary Art, Barcelona, p. 197.

Murray-Leslie, A. 2015, ‘Alexandra Murray-Leslie (Chicks on Speed)’, in T. Grandas T, B. Preciado & A. Dressen (eds), *La passione secondo Carol Rama*, Silvana Editoriale, Torino, p. 250.

Murray-Leslie, A. 2015, ‘Footwerk: Improvisations in gender, sound and space’, in K. Moline & P. Hal (eds), *Experimental thinking: Design practices*, Griffith University Art Gallery, Brisbane, pp. 10-17.

Murray-Leslie, A. 2015, *High techne fashion design*, Design Friends, Luxembourg.

Murray-Leslie, A. & Logan, M. 2015, ‘Golden Gang’ in R.B. Buhrs (ed.), *Der stachel des skorpions: ein cadavre exquis nach Luis Buñuels "L'Âge d'or"*, 1st edn, Hatje Cantz Verlag GmbH, Munich, pp. 25-48.

Ferguson, S.J., Johnston, A. & Murray-Leslie, A. 2014, ‘Methodologies with fashion acoustics live on stage!’, *Proceedings of the International Conference on New Interfaces for Musical Expression, Goldsmiths, London*.

Murray-Leslie, A. & Ferguson, S. 2014, ‘Fashion acoustics: Synthesizing wearable electronics and digital musical instruments for performance’, *Critical Studies in Fashion & Beauty*, vol. 5, no. 1, pp. 141-161.

Murray-Leslie, A.N. & Logan, M. 2014, ‘U is for utopia’, in S. Pollak (ed.), *Schwimmende städte, fliegende häuser…: Zur utopie der stadt*, Sonderzahl Verlag, Vienna, pp. 64-69.

Murray-Leslie, A.N. & Logan, M. 2014, ‘Visitors’, in B. Knaup & B.E. Stammer (eds), *Re.act.feminism: a performing archive*, Moderne Kunst Nürnberg, Live Art Development Agency, London, pp. 152-153.

Murray-Leslie, A.N. 2014 ‘Colour tuning’, *Costume Colloquium IV: Colours in Fashion*, Auditorium Al Duomo, Florence.

Murray-Leslie, A. & Johnston, A. 2013, ‘ESHOE: a high heeled shoe guitar’, *ISWC International Symposium on Wearable Computing, ACM Conference on Ubiquitous Computing*, UbiComp'13 Adjunct, Zurich.

Appendix C

Artist in Residence, Research Fellowships and Creative Company Partnerships

2018

April-December

Protopixel, Barcelona, ES

Creative Company Partner

September-December

NTNU, Norwegian University for Science and Technology

ARTEC Artist in Residence

2017

January-October

Music Technology Group, University Pompeu Fabra, Barcelona, ES

Collaboration with Dr. Sergi Jorda

January, May and July (3 x 2 day visits)

CCC (Critical, Curatorial, Cybermedia Studies), HEAD,

The University of Art and Design, Geneva, CH

Research Affiliate

August-September

Moog Sound Lab, Science Gallery Dublin, IE

Artist in Residence

October-September

Reactable Systems, Barcelona, ES

Creative Company Partner

October-September

Protopixel, Barcelona, ES

Creative Company Partner

2016

January, May and July (3 x 2 day visits)

CCC (Critical, Curatorial, Cybermedia Studies), HEAD, The University of Art and Design, Geneva, CH

Research Affiliate

April

Department of Music Studies, Ionion University Corfu, GR

Collaboration with Dr. Sam Ferguson

Academic Artist Research Fellow

August-December

Pier 9 Technology Centre, Autodesk, San Francisco, US

Academic Artist Research Fellow

2015

January-September

Music Technology Group, University Pompeu Fabra, Barcelona, ES

Academic Artist Research Fellow

April

EAVI - Embodied AudioVisual Interaction Group - Goldsmiths University of London, UK

Collaborating with Dr. Rebecca Fiebrink

Academic Artist Research Fellow

March-August

Nanyang Technological University, Centre for Contemporary Art Singapore, SG

Artist in Residence

2014

March-April

Biomechanics Laboratory, Department of Kinesiology, College of Health and Human Development, Pennsylvania State University, US

Collaboration with Dr. Jonas Rubenson

Artist in Residence

January-February

Freemantle Arts Centre, AU

Artist in Residence

2013

January-April

ArtSpace Sydney, AU

Artist in Residence

January-February

Museum of Old and New Art, Tasmania, AU

Artist in Residence

April-September

StretchSense Auckland, NZ

Creative Company Partner

July-September

Institute of Modern Art, Brisbane, AU

Artist in Residence

October

ZKM, Centre for Art and Media, Karlsruhe, DE

Artist in Residence

November-December

SymbioticA, Centre for Excellence in Biological Arts, The University of Western Australia, AU

Artist in Residence

Appendix D

Funding, Awards and Prizes

2013-2016	The University of Technology Sydney, Vice Chancellor's Research Scholarship
	Australian Government Postgraduate Award
2013	Australia Council for the Arts Development Grant: Stipend, travel and research funding
	Goethe Institute: Travel and project funding
	Music NSW, Quick Response Grant: Stipend, travel and research funding
	A Shaded View on Fashion Film Barcelona: Best Music Award
2014	Australia Council for the Arts: Travel funding
	The University of Technology Sydney, Vice Chancellor's Conference Fund: Travel funding and conference presentation
	Goethe Institute: Travel and project funding
	IFA Institut für Auslandsbeziehungen: Travel, media and exhibition funding
	TBA Thyssen Bornemisza Art Contemporary 21: Commission
2014-15	Bundeskulturstiftung Germany: Project funding
2015	Nanyang Technological University, Centre for Contemporary Art, Singapore: Artist fellowship grant
2016	The University of Technology Sydney, Vice Chancellor's Conference Fund: Stipend and conference presentation

	The University of Technology Sydney, Faculty of Engineering and IT: Travel, stipend and conference presentation
	SEAC South Eastern College of Art Conference Sarasota: Artist fellowship
	ZKM Centre for Art and Media, Karlsruhe: Commission
	Autodesk Technology Centre, Pier 9, San Francisco: Stipend, research and prototyping expenses
2017	The University of Technology Sydney, Faculty of Engineering and IT Postgraduate Funding: Prototyping expenses
	The University of Technology Sydney, Faculty of Engineering and IT: Travel, stipend and conference presentation European Research Council: Project funding
2018	Guthman Musical Instrument Competition, Georgia Tech, Atlanta: Semi-finalist
	ARTEC, NTNU, Norwegian University of Science and Technology: Artist fellowship grant

Appendix E

Definition of Terms

Artistic Practice

Something we do that goes beyond everyday thinking and actions that may lead to new artefacts and outcomes which could be in the form of art works, lens based documentation of processes of making, musical compositions, designs or performances. Combining the act of creating something unique with the necessary processes and techniques belonging to a given field, whether art, music, design, engineering or science (Candy & Edmonds 2018).

Acoustic fashion objects

A term I coined, is the synthesis between wearable computers and fashion for art performances. The acoustic fashion objects, specifically the technology research project for this PhD are acoustically and visually aesthetic shoes.

Pre-prototypes (BipedShoes)

The title I coined to describe the first prototypes, like biped using two feet for walking.

Computer enhanced footwear

I use the term *computer enhanced foot-wear* in this thesis to refer to electro-mechanically enhanced shoes or temporary foot-appendages, high-heeled shoes, devices and apparatus, which have the ability to receive and process sensor information (embedded with microcontrollers, circuits and sensors), sense foot movements, and create theatrical audiovisual effects on stage afforded by the feet.

Cross-disciplinary

Multidisciplinary or transdisciplinary, relating to or representing more than one branch of knowledge.

Deinscribing

Griselda Pollock (1996) introduces 'radical underfeminization'; the dilemma for women artists in the early 19th century to produce work inside the cannon of modern male artistic production and the need for an 'inscription in the feminine' in the future work made by women. I draw parallels to Pollock's statement to technology which has ultimately shaped the form, function and aesthetics of footwear for better or worse (as the literature shows), which has ultimately led to shoes shaping our feet, (Bernard Rudovsky describing modern shoes as 'foot deformers' in 1947). This practice based research attempts to metaphorically deinscribe the high-heeled shoe to liberate the feet to create a new 'inscription of the feminine' (Pollock 1996).

Dramaturgy

The art of dramatic composition and the representation of the main elements of drama on the stage. In the context of this research, dramaturgy is used to analyse relations among action and wearable digital musical instruments and how this impacts the creative development of an entire performance.

Demaking

A term I coined to liken the process of 'demaking' the high-heeled shoe in order to give it a new purpose and create new experiences for the wearer. This builds on the traditional uses of footwear as mentioned in the literature. As an example of Demaking; Deleuze discusses the notion of changing the purpose of the hands to the feet. The below quote summarises how this can result in the 'composition' or rearrangement of, 'the overall assemblage' (Deleuze & Guattari, p. 1980), which I term 'Demaking' the original artefact. Deleuze's character Slepian gets the idea of using shoes to change his identity to a dog using the artifice of shoes.

> If I wear shoes on my hands, then their elements will enter into a new relation, resulting in the affect or becoming I seek. But how will I be able to tie the shoe on my second hand, once the first is already occupied? With my mouth, which in turn receives an investment in the assemblage, becoming a dog muzzle, insofar as a dog muzzle is now used to tie shoes. At each stage of the problem, what needs to be done is not to

> compare two organs but to place elements or materials in a relation that uproots the organ from its specificity, making it become 'with' the other organ (Deleuze & Guattari, p. 1980).

All aspects of this research attempt to 'demake' the physical high-heeled shoe. I suggest 'demaking' the high-heeled shoe through underlying concepts based on the literature and computer aided fabrication processes, to create new forms of expressive audio-visual foot devices. The process 'demaking' also changes the usual purpose of shoes and associated stereotypes of high-heeled shoe wear. 'Demaking' is the same as 'defamiliarisation' or 'deinscribing'.

Extranormal

Outside or beyond what is normal. Extranormal in this thesis is used to describe unusual movements of the feet to perform *computer enhanced footwear*.

Fashionable costume

Is a garment inspired by contemporary fashion trends and is simultaneously a bespoke costume for theatrical expression on stage. This fashionable costume also has the possibility of inspiring actual fashion trends and feeding back into the fashion system. This research is concerned with costuming the foot in such a way.

Humanistic Intelligence (HI)

Steve Mann's (2001) vision for Humanistic intelligence was a signal processing framework in which the processing apparatus is inextricably intertwined with the natural capabilities of our human body and mind, it was a vision that directly resulted in the founding of the MIT Media Lab's Wearable Computing Project[224] and, consequently, the establishment of the field of wearable computing. Though this project isn't about creating systems, the approach is applied to using circuits and systems in conjunction with physical prototypes and how they are used. The *computer enhanced footwear* seek to extend the body with technology following principles of humanistic intelligence (Mann 2001) promoting a vision that puts human beings and the

[224] For more information on Steve Mann's Humanistic Intelligence visit: http://wearcam.org/nn.htm

creative act at the centre of technological development (Mann et al 2013). In my opinion, there is a relationship between the Anthropotechnological and HI.

Gesamtkunstwerk[225]

An 'all encompassing artwork', 'total work of art', 'synthesis of the arts' or a work that encorporates many other art forms. The term was first used by German writer and philosopher K.F.E. Trahndorff in an essay[226] in 1827, followed by German opera composer Richard Wagner using the term in 2 essays in 1849 and became the basis of how he went about writing and creating his works. "According to Wagner, the *'Zersplitterung der Kűste'* (*the Split between the Arts*) had occurred in Greek antiquity, with word, music and dance originally existing in perfect harmony. Initially, in the perfect Greek state, Greek tragedy embodied this harmony, but with the fall of the 'Athenian Polis', the arts started to diverge" (Rehn Wolfman 2013). Gesamtkunstwerk is usaually applied to theatre works, opera, art installations or architectural projects. I suggest it can also be applied to an object like the *computer enhanced footwear* that consist of many parts and cross-disciplinary fields of knowledge, that went into creating the artefact. I also use the term as a way to describe artistic processes of making and prototyping, as being interconnected in the final artefact and a form of **gesamtkunstwerk thinking**.

New interfaces for musical expression

New Interfaces for Musical Expression, also known as NIME, is an international conference dedicated to scientific research on the development of new technologies and their role in musical expression and artistic performance.

NUIs (natural user interfaces)

Steve Mann explained in 2007 NUI's are an emerging trend which seek to customise computing to human capacities and abilities. Black (2013) suggests NUI allow "computers and human beings to interact in diverse and robust ways, tailored to the abilities and needs of an individual user (.....) which allow for complex interaction with digital objects in our physical world" (Black

[225] For further information on Richard Wagner's gesamtkunstwerk approach and work: Wagner, Richard (1993), tr. W. Ashton Ellis *The Art-Work of the Future and Other Works.* Lincoln and London
Millington, Barry (ed.) (1992) *The Wagner Compendium: A Guide to Wagner's Life and Music.* Thames and Hudson Ltd., London.
[226] Trahndorff (1827), *Ästhetik oder Lehre von Weltanschauung und Kunst*

2013, p. 5). Mann supports the idea of humanistic intelligence, using machine learning for human personal needs and sees the work of Rebecca Fiebrink (computer scientist who developed Wekinator, machine learning for artists, who I also collaborated with later in the thesis) as valuable on the scale of humanistic intelligence, in conjunction with discussions around "Technology and Society" Mann addresses on several occasions (Mann 2013, pp. 1) and in a personal discussion I had with him at Autodesk in December 2017. In a similar way, **Haute Couture** customised clothing is made for individuals to attempt "to give substance to a fantasy and to create a theatrical effect" (Wollen 1998, p. 8). In a modern context, it's possible to imagine a pairing of Haute Couture and NUIs to customising interfaces for abilities and capacities of particular performers, rather than designing a 'ready-to-wear' interface that is designed to be all things for all performers. Haute Couture concepts paired with NUIs have the potential to deliver individual acoustic traits in a scene of a performance, maximizing the 'uniqueness' or 'newness-effect' of the acoustic fashion objects as perceived by the audience and influencing the creative development of a performance and its dramaturgy.

Synectics

Described by its creator, William J. J. Gordon, as "the joining together of different and apparently irrelevant elements. Synetics theory aplies to the integration of diverse individuals into a problem-stating-problem-solving group" (Gordon 1961, p. 3)." (Gordon, 1961, p.5). The term Synectics, from the Greek 'syn' and 'ektos', refers to the fusion of diverse ideas (Nolan, 2003, p. 25). The process of Synectics is a "metaphor/analogy-based technique for bringing different elements together in a search for new ideas or solutions" (Starko, 2010, p. 151). I have applied Gordon's Synetics theories to aspects of my creative practice case studies, particularly the way I worked with giving the dancers a series of metaphors to enact with the prototypes. I have also stated specifically in the case studies where I have used Synetics and why. Synetics can also be related to notions of 'making strange' and alternate uses tests.

Sonification

The conversion of data into sound.The use of non-speech sound to convey or represent data sonically from an electronic device.

Suspension of disbelief

A "phrase for the voluntary withholding of scepticism on the part of the reader with regard to incredible characters and events" (Oxford Dictionary). The term was coined by poet and aesthetic philosopher Samuel Taylor Coleridge in 1817 and means the willingness to suspend one's critical faculties and believe the unbelievable; sacrifice of realism and logic for the sake of enjoyment. 'Suspension of disbelief' is often an essential element for a magic act or a circus sideshow act. For example, an audience is not expected to actually believe that a woman is cut in half or fly's through the air in order to enjoy the performance. 'Suspension of disbelief is an essential ingredient for any kind of storytelling, poetic narrative and is commonly used in pop music performance and theatrical productions.

Appendix F

Project Acknowledgements

Pre-prototype (BipedShoes)

Sam Ferguson: gesture≈sound programming

Alexandra Murray-Leslie and Sam Ferguson: interaction design and hardware

Bruno Magli (Max Kibardin): shoe design

Prototype Hits:

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SEAM13: Conference, Authorship, Curation, Audience, Drill Hall, Sydney

MCA, Centre for Contemporary Art Australia

Special thanks to Prof. Jon Drummond and Blair French, Margie Medlin, Benedict Anderson and Paul Gazzola

Producer: Kim Lenoble

Dancers: Billy Lime and *The Lycra Ladies*

Textile Banners: screen printing Johnny Dogday, sewing Kathi Glas

Concept and Direction: Alexandra Murray-Leslie

***Computer Enhanced Footwear* Prototype 1**

SymbioticA, The Centre of Excellence in Biological Arts, School of Anatomy and Human Biology, University of Western Australia: development

Biomechanics Laboratory, College of Health and Human Development, The Pennsylvania State University

NTU, Centre for Contemporary Art Singapore

Creativity and Cognition Studios, Department of Engineering and IT, The University of Technology, Sydney

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Sam Ferguson: Xbee and Arduino programming, gesture≈sound coding, consultation and construction of heel

Alexandra Murray-Leslie and Sam Ferguson: interaction design and circuit building

Andrew Johnston: consultation

Jeffrey Hong: Revised heel 3d scanning, revised heel 3d printing

Alexandra Murray-Leslie: heel design

Bruno Magli (Max Kibardin): Shoe design

Nanyang Technological University, School of Art, Design and Media: production residency

Lab based visualisation and sonification experiments

Biomechanics Laboratory, College of Health and Human Development, The Pennsylvania State University

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Cynthia White: documentation

FOOTwerk, Singapore:

The Art of Work 1 and *Footwerk: Open Studios*

NTU, Centre for Contemporary Art Singapore

The Art of Work 2

ArtScience Museum Singapore

Special thanks to Honor Harger and prof. Ute Meta Bauer

Anca Rujoiu: curation

Vera Arunee Camindo Mey: production

Marla Bendini: pole dancer

Performers: Alexandra Murray-Leslie, Melissa Logan and Lennat Mak

Kenneth Feinstein: documentation and film collaboration

Dinu Boddiciu: Costume

Alexandra Murray-Leslie: Concept, direction and gesture≈sound real-time filtering

FOOTwerk, European tour:

Performers: Melissa Logan, Alexandra Murray-Leslie

Choreographer: Krõõt Juurak

Drummer: Mathias Brendel

Performers: Alexandra Murray-Leslie and Melissa Logan

Costume: Bruno Magli (Max Kibardin) and Dinu Boddiciu

Lighting design: Djana Covic

Concept, direction and gesture≈sound real-time interaction Max/MSP:

Alexandra Murray-Leslie

AVANTGARDENING & DEMAKING IN HAVOCS HAVENLY KINGDOM

Kunsthalle Basel

Fashion Institute of Fashion Design, Academy of Art and Design, FHNW Basel

Special thanks to Maria Loboda

Performers: Alexandra Murray-Leslie, Priska Morger, Djana Covic, Nico de Rooij and Marco Papiro

Choreographer: Kihako Narisawa

Performance concept: Priska Morger, Djana Covic & Alexandra Murray-Leslie

Fashion, shoes, accessories, props and videos: Anja Bodenmann, Nina Britschgi, Wendy Buck, Hannah Campbell, Maya Christofori, Marion Ihly, Nina Jaun,Ronja Kösters, Michèle Merz, Lea Metzger,Nadine Möckli, Nina Savenberg, Julia Stöcklin, Chiara Strozzega and Lina Widmer.

***Computer Enhanced Footwear* Prototype 2**

Nanyang Technological University, School of Art, Design and Media fabrication lab.

Music Technology Group, University Pompeu Fabra: lab space

Alexandra Murray-Leslie: concept and design

Jeffrey Hong: consultation, 3d renderings

FOOTwerk, Germany:

Artstravaganza by Chicks on Speed, *Karl Lagerfeld. Modemethode* exhibition

Bundeskunsthalle Bonn

Producer Bundeskunsthalle: Johanna Adam

Producer Chicks on Speed: Christoph Storbeck

Choreographer: Krõõt Juurak

Performers: Krõõt Juurak, Alexandra Murray-Leslie and Melissa Logan

Costumes, shoes and facinators: Bruno Magli (Max Kibardin), Dinu Boddiciu and House of Chang

Concept, direction and gesture≈sound real-time interaction Max/MSP: Alexandra Murray-Leslie

Machine learning experiments

Technology partner: Stretchsense Auckland

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Rebecca Fiebrink: machine learning and programming Wekinator, Max/MSP and Reaktor

Sam Ferguson: Machine learning and programming Wekinator, Max/MSP

EAVI Embodied AudioVisual Interaction Group

Goldsmiths University of London: workspace

C4DM, Centre for Digital Music, Queen Mary University of London: workshop space

Department of Music Studies, Ionian University, Corfu: workspace

***Computer Enhanced Footwear* Prototype 3**

Pier 9 Technology Centre, Autodesk, San Francisco

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Alex Reed: Shoe engineering consultation

Alexandra Murray-Leslie: 3d design and fabrication

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Pere Calopa Piedra: Max/MSP and Abelton Live programming

Daniel Gallardo Grassot: ProtoPixel lighting effects system programming

CEF P3 live 1:

Yo Sissy Festival, Berlin

Performers: Melissa Logan and Alexandra Murray-Leslie

Dummer: Saskia von Klitzing

Costumes: concept Alexandra Murray-leslie, made by Kathi Glas

Concept, direction and gesture≈sound real-time interaction Max/MSP: Alexandra Murray-Leslie

CEF P3 live 2: *The Liberation of the feet: Demaking the High Heeled Shoe for Theatrical Audiovisual Expression*

Ars Electronica Festival, Linz

Artistic Directors: Gerfried Stocker and Christiane Schöpf:

Curator and producer: Hannes Franks

Choreographer: Krõõt Juurak

Costumes: Kathi Glas

Performers: Krõõt Juurak and Alexandra Murray-Leslie

Visualist and documentation: Wolf-Dieter Grabner

Scenography: Boomesch Tak

Concept and direction: Alexandra Murray-Leslie

Concept, direction and gesture≈sound real-time interaction Max/MSP:
Alexandra Murray-Leslie

Appendix G

List of Figures and Tables