ALMOST HUMAN: THE STUDY OF PHYSICAL PROCESSES AND
THE PERFORMANCE OF A PROSTHETIC DIGITAL SPINE

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ABSTRACT

Almost Human is an investigation of interdisciplinary performance through music that looks to the self to try to further understand subjective performance practices in expression, gesture and sonic output. This text presents experimental methods of examining and creating music through kinaesthetic and electronic-assisted means within instrumental, dance and interactive works. The extraction of affective, performative and sonic properties from these works aids in unlocking the relationship between the choreographic, physical and conceptual object.

The first part of the text explores and illustrates multimodal approaches to analysing, capturing, measuring and archiving the moving musician and dancer in an assortment of performative settings. It focuses on a series of works for solo cello, as well as interdisciplinary pieces which positions movement and embodied expressivity at the forefront of the discussion.

The second part is dedicated to the aesthetic, conceptual and utilitarian content of a new interactive work for cellist/mover, and a prosthetic digital spine. Here, relationships are combined to showcase the permeability of the body, as well as its expressive content. The conceptual object, The Spine, serves as a generator to help expand musical and artistic possibilities. Its inclusion in the work aids in refocusing my relationship to movement and sound for creation and performance, but also aesthetically, it adds to the growing canon of experimental ventures in conceptualising expressivity.

Beyond the text, the portfolio of Almost Human includes an auditory and visual chronicle of the process between the years 2012-14, which is used to assist the reader in further understanding the performative practice and findings.

ACKNOWLEDGEMENT

"We all have the illusion that we're playing ourselves.
We are always performing. Right now I perform the role of an
 artist speaking about her work." — Meg Stuart

INTRODUCTION

In a collection of essays on music, sound and space published in 2013, anthropologist Georgina Born quoted composer Edgard Varèse, 'When new instruments allow me to write music as I conceive it, the movement of sound-masses, of shifting planes, will be clearly perceived in my work, taking the place of linear counterpoint. When these sound masses collide, the phenomena of penetration or repulsion will seem to occur' (Born, 2013, p.1). Born quotes Varèse to not only structure the content of the book, but also to show the significance of sound, space, temporality and physicality in the music of the twentieth and twenty-first century. As listeners, we are positioned in an age of immediacy with infinite ways to experience music, noise, power, and force. With such experiences revolving around me daily, I embarked on the research presented in this thesis because of an interest in reconnecting with dance as a performer, and a growing interest in developing and incorporating wearable technologies into my performative practice that would alter the way in which I, as well as audiences viewed visual and sonic arts.

This PhD portfolio presents experimental methods of examining and creating music through kinaesthetic and electronic-assisted means. Studies of the body in regard to musical, aural, and visual perception are numerous; my work looks to the *self* to try to further understand subjective performance practices in expression, gesture and aural output. Literary and cultural theorist, Steven Connor, argues that 'The *self* defined in terms of hearing rather than sight is a self imagined not as a point, but as a membrane... a channel through which voices, noises and musics travel' (Connor, 1996, p. 206). The embodied self is examined in this thesis as the membrane through which expression and gesture are given a place to resound. This PhD makes a new contribution

to the growing corpus of research not only within adaptations of Rudolf Laban's kinetography theories to instrumentalist's, in regard to innate body awareness, and cognitive sciences, but also concerning the transformation of physicality to music, the scripting and personal experience that lies within.[1] The composer, Paul Craenen, in his exploration of physicality in composition argues,

> ...it is not the form of the music that resonates, but the physical 'will to sound,' or the continual possibility of expressing physical and spatial presence in sound. It is not the sounds themselves that are the message, but the resonance of their physical, local and temporal origin (Craenen, 2013, p. 1.3).

In looking beyond the surface of notation and the sound affect, the possibility for a heightened level of performativity can be reached.

This practice-led research in the evaluation of subjective performance practices, self-analysis and physical/aural transformation stems from years of performance and observation of fellow professional musicians, and conservatory students. Haseman, in his manifesto on performative research, states that performative *research* is a third research paradigm, contrasting traditional quantitative and qualitative paradigms and methodologies (Haseman, 2006). Due to the lack of clearly defined research models, practice-led researchers have had to find new avenues to ensure their research is aligned with other academic research models. Performative research includes participant, participatory, collaborative, action research strategies, and utilises reflective and peer review methods. This research draws in part upon all these strategies to varying degrees. Cello performance is referenced in part because it is my own practice, but also because of its relevance to the present investigation: its highly visual motor-action profile, and close connection to the broad moving body.

Underpinning every aspect of this research is Rudolf Laban's Movement Analysis (LMA). LMA is used to examine human movement behaviour, mostly in the form of

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[1] Scripting is a term found in theatre arts, dance and computer science that involves the writing of a programme of dance sequence or staging. It is used it in the context of dance to suggest the organised writing of movement.

expressivity, gestural intention, and action. Unifying these areas is the principle that observable movement reflects the individual's inner motivation for movement (Bartenieff & Lewis, 1980) and the techniques used to observe and analyse action. In my work, I take into account embodied experiences that arise from physical experiences and kinaesthetic approaches that are based on the subjective observer. LMA has been used in a wide range of settings to analyse movement in dance (Bartenieff et al.,1984) and music (Mullins, 2009; Broughton and Stevens, 2012) and has informed a number of anthropological studies (Jablonko & Kagan, 1988). My work applies Laban's Choreutics and Eukinetics, as well as his *Eight Basic Efforts,* to express movement patterns perceived in performance. The findings of these expressive movements are then later used as source material to transform instrumental expressive gestures from an acoustic instrument to a digital interface in the form of a prosthetic spine.

One of the aims of the present study is to investigate the adaptability of LMA to cello performance, to use it as another means for understanding expressive movement as well as helping to draw a correlation between musical composition and transformative aural and visual output. The design of the study was observational, and hands-on participatory. I hypothesised that following training in LMA and Laban's notational symbols, my subjective observation of movement in my practice as well as that of others would be heightened and would corroborate my ideas on the enhancement of mobility and embodiment in musicians in both acoustic and mixed-music settings.

This PhD portfolio consists of the present thesis on research conducted over the course of 2012 to 2014. Alongside the submission of this thesis, I include:

- Sketches from movement segments in Labanotation and freehand,
- Scores from commissioned works by composers Patricia Alessandrini and Edward Hamel, as well as those by J. S. Bach (manuscript and annotated performance), Lachenmann, Gabriele, Ian Hattwick (for the musical score for *Almost Human*),

- Interviews with dancers, choreographers and musicians on the collaborative process and self-reflection on movement
- Video:
    - Motion Capture sessions and plotted data
    - live performances of all instrumental works discussed (including session with cellist Elinor Frey)
    - The Quartet collaboration with the dance company, SINE QUA NON
    - The Funerals with Ictus and P.A.R.T.S, performance of *Almost Human* (workshop rehearsal before the electronics were designed and the premiere performance in London at the NIME Conference),
- Still images of the prosthetic spines, clips of gesture transformations and Max MSP patches for running the performance of *Almost Human*.

The thesis has two main parts divided into five chapters. Part 1 consists of chapters 1 to 4 and deals with the analysis of expressive movement in regard to actions, embodiment, and scripting which is then juxtaposed against the performance and practices of both a musician and dancer. It is paired this way because of the close similarities found in the highly animated cellist and the contemporary dancer. Part 2, beginning with chapter 5, deals with the study of a specialised digital instrument created at McGill University, and the transformation of expressive gestures examined in the first section through case studies. The gestures that are derived from the performative practices of a musician are then transformed to create a new performance work utilising a prosthetic digital instrument.

The first chapter focuses on notions of gesture and affordance, by grounding the research on theories and commentary by Claude Cadoz, Marcelo Wanderley, and Anthony Gritten. This chapter also outlines the three strands of gesture functions that are used to shape its usage in the forthcoming chapters.

The second chapter focuses on Rudolf Laban's movement theories, *Choreutics and Eukinetics*, and how they frame the thinking and progression of the entire research. I

focus my work around Laban's *Eight Basic Efforts* to decipher basic and "harmonised" movement. Examples of notation symbols from the LMA (Laban Movement Analysis) that are primarily used in my work and analysis are also presented here.

The third chapter deals exclusively with case study examinations of the solo cello works that made the most impact. The discussion focuses exclusively on compositions by composers Helmut Lachenmann, Edward Hamel, and J. S. Bach, whose works yielded the best results in motion capture and video analysis. As previously stated in Chapter two, the focus will primarily be on demonstrating the use of Laban's *Eight Basic Efforts* in instrumental playing and how examples in Instrumental Gestures, movement directly connected to sound through aural and visual means, and Ancillary Gestures, movement that has a supportive correlation to sound production. This work is supported by the research outputs of Jan Schracher, Baptiste Caramiaux and Marcelo Wanderley in Motion Capture.

The fourth chapter focuses directly on experimental contemporary works that involve dancers and musicians. It focuses on the collaborative work in developing movement, and the deciphering and scoring of expressive movements and gestures that eventually yield an artistic work. This section is built on the collaborative work with composer Patricia Alessandrini, dance company SINE QUA NON, and the published writings on deciphering and tuning subjective movement in dancers/choreographers William Forsythe and Meg Stuart. It was in the collaborative process that I truly began to understand ways to sonify the body on an "acoustic" level. In this chapter I explain the investigation process as well as my experiences in adapting musical material to dancing bodies and vice versa. Outcomes of the findings are informed by interviews with choreographers, dancers and musicians (see The Funerals Questionnaires).

Chapter five is divided into three subsections that give a concise look at work involving Bio-kinetic and Experimental Performance. This chapter segues from the

initial "acoustic" analysis done in Motion Capture, dance movement and Laban notation into the work done on sound interfaces and performance practices. The first section discusses a brief history of wearable technologies for expressive performance. A brief introduction to the release of the MIDI in 1984, as well as its usage towards more experimental instruments for personal performance is discussed.

The second section introduces the Prosthetic Spine, which is part of a family of digital musical instruments (DMI) used for interactive performance. A concise breakdown of its history and development is discussed as well as the mechanical and technical design.

The final section explores the year long residency that produced a substantial body of work. It examines the initial experimentation with the previous Laban scores, motion capture footage, and further explains transforming instrumental gestures to full body choreography. This stage focused primarily on expressivity in performance and how these "moments" allow for physical and sonic expansion through: a) a new instrument for musical expression and b) embodied listening and performance that goes beyond that of a traditional instrument. The culmination of the detailed technical and artistic methodology will show the steps taken to uncover a deeper understanding of the instrumentalist's body as well as its expressive functionality with a traditional and digital-age instrument. The findings from the forthcoming chapters have helped me not only redefine my practice in regard to cello performance, but also in interactive settings with wearable technologies.

PART I

Identities, Structures, Performance

CHAPTER ONE

Notions of Gesture and Affordance

This chapter examines the relationship between *gesture* and *affordance*, and its relevance to the works discussed in the forthcoming chapters. These terms, gesture and affordance, have a complex network of meanings and associations which warrants further exploration.

1.1 GESTURE

The projects presented in this portfolio all approach gesture(s) and movement through various lenses to strengthen and facilitate a heightened understanding of instrumental movement. Discussion of gesture as it pertains to movement revolves around experimental explorations of performance through fragmenting, reordering, and transforming physical movement.

Movement, action, intention

> An object encounters its image, and objects encounters its name. It happens that the image and the name of this object encounter each other.-William Forsythe (BeautyQuark, 2012)

Gesture, for me, comes out of my personal association with a struggle to communicate, socio-political restraints, as well as a negotiation to find a language, both musical and spoken, to communicate emotions. The distinction between motion or movement, action and intention as it relates to gesture is a central issue in this discussion. The transition from movement to gesture must be examined.

According to Cadoz & Wanderley, the term 'gesture' is used to denote physical actions that are connected to speech and coexist with it (McNeill, 2005). Linguistically, gestures can be both voluntary and involuntary movements which accompany motions, and are also known to have individual symbolic meanings. Gallagher states:

> Although speech and gesture depend on movement as a necessary condition, they nonetheless transcend motility and move us into a semantic space that is also a pragmatic, inter-subjective, inter-corporeal space...the body 'lends itself' to gesture, gesture is never a mere motor phenomenon; it draws the body into psychological and communicative orders defined by their own pragmatic rules (Gallagher, 2005, p. 122).

In using the body as an expressive vehicle, gesture then becomes instrumental in communicating a plethora of intentions, regardless of setting.

Shifting the concept of gesture from linguistic understanding to the realm of musical production, it could be stated that a musical gesture is an action pattern that produces music or is encoded in music, but that simply 'ignores the semantic components that gestures inevitably carry' (Schacher, 2012, p. 194). If gesture is thought of both as a linguistic tool and a derivative of motion, it is then possible to say that it is the result of an intention alongside movement. Movement is to action as intention is to gesture. Therefore, actions are constituted by movements and further accented by intentions.

Sound and its connection to music in its rawest state, stems from a movement and an action. In relation to my research in music and movement, the goal is to find a way to make the disciplines and their respective linguistic theories, music and dance,

interchangeable.[2] This is not a mere focus on cross-disciplinary collaboration, but a way to see where the disparate forms could assume properties of each other, regardless of how personal. Analysis of my work is executed through the negotiation of sound by use of found and prepared movements and actions. As both areas belong to art, Lyotard states: 'art is not merely a cultural object, though it is that too. It harbours within it an excess, a rapture, a potential of associations that overflows all the determinations of its "reception" and "production" '(Lyotard, 1991, p. 92). Gestures, wide and varying, are universal, but the focus on reception, process and intention leads us to understand them better.

1.2 GESTURAL STRANDS

The relationship of movement to sound is problematised; they are either thought of as unified, their differences minimised, or the asymmetry of the distinction is irritated. I am working towards a situation in which one has a tendency to become more aware of the ways that sound and the world effectuate one another. This awareness may open a space for affect, as we experience sound with our own bodies, as this kinetic empathy "causes a stir deep in bodily layers" (Grimes).

There has been a renewed interest in gesture, both musical, physical and sounding in the last 10 to 15 years which has produced significant new musical scholarship in its

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[2] Although both mediums are based on expression, the terminology tends to differ or even conflict. At the core of both, I believe many of the same principles apply, regardless of the variance in terminology.

design,[3] function,[4] and interaction between performer and musical content.[5] These

practice-based outputs have been created to address not only standard performance

practices in classical music such as ancillary gestures in clarinet performance or

preparatory gestures in playing the timpani,[6] but also the design and function of gesture

and its relation to experimental, acoustic and electronic music.[7]

Many of these will be discussed later in the thesis. Where past research on music and

gesture models examined performance and musical scores objectively, current

scholarship has given way to empirically grounded research that now affords researchers

and practitioners the possibility to measure gesture through computing technology,

create typologies of sounding gestures[8] that are situated in 'mixed' music, as well as

adopting analytical models formally used for organised events (1936 Olympic Games with

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[3] Examples of design can be found in the following research: Kvifte, T. and A. R. Jensenius (2006). Towards a coherent terminology and model of instrument description and design. In N. Schnell, F. Bevilacqua, M. Lyons, and A. Tanaka (Eds.), *Proceedings of New Interfaces for Musical Expression, NIME 06, IRCAM - Centre Pompidou, Paris, France, June 4-8*, pp. 220–225. Paris: IRCAM - Centre Pompidou, and Aksnes, H. Music and its Resonating Body, *Dansk Årbog for Musikforskning 2001*, vol. XXIX, 2002, pp. 81-101.

[4] Technical and functional usage of gesture: Jensenius, A. R. , R. I. Godøy, and M. M. Wanderley.(2005). Developing tools for studying musical gestures within the Max/MSP/Jitter environment. *In Proceedings of the International Music Computer Conference*, Barcelona, pages 282–285.
Godøy, R.I.(2006). Coarticulated gestural-sonorous objects in music.*Second International Conference on Music and Gesture*, Royal Northern College of Music, Manchester (UK).
Delalande, F. (1988). "La gestique de Gould: éléments pour une sémiologie du geste musical."
In G. Guertin, ed. Glenn Gould, Pluriel. Louise Courteau Editrice Inc. pp. 83-111.

[5] Performer interactions can be found in the following readings: Lewis, A. and Pestova, X. (2012). The Audible and the Physical : a Gestural Topology for 'Mixed' Electronic Music. *In Proceedings of the Electroacoustic Music Studies Network Conference*, Stockholm June.
Godøy, R.I, E. Haga, and A. R. Jensenius. (2006). Exploring Music-Related Gestures by Sound-Tracing. - A Preliminary Study. *2nd ConGAS International Symposium on Gesture Interfaces for Multimedia Systems*, Leeds.

[6] Examples of research utilising the clarinet and timpani to discover ancillary and preparatory gestures may be found below:
Savard, Alexandre.(2009). When gestures are perceived through sounds: A framework for sonification of musicians' ancillary gestures. Diss. McGill University.
A. Bouënard, M. M. Wanderley and S. Gibet. (2009). "Analysis of Timpani Preparatory Gesture Parameterisation". *In Proc. of the International Gesture Workshop* (GW), pp. 61-62, Bielefeld, Germany.

[7] The lack of published research for peers to learn from, especially practise-based for electronic/electro-acoustic, led to the founding of the NIME in 2001. The fact that a conference of such esteem only exists since 2001 is somewhat of an indication of gesture and expressivity being a key factory in electro-acoustic practices since that time.

[8] In a conference article on 'sounding gesture' (2012), Andrew Lewis and Xenia Pestova define sounding gesture as 'that which is heard in the sound that suggests the action performed to make it.'

Rudolf Laban), dancers (Forsythe, Graham and Brown), and industrial factories (Ford Assembly Line).

Of the extensive scholarly research done on musical gestures, the broadly grounded semiotic understanding of gesture (within music) is what musicologist Anthony Gritten (2006) defines as 'a movement or change in state that becomes marked as significant by an agent. This is to say that for a movement or sound to be(come) a gesture, it must be taken intentionally by an interpreter, who may or may not be involved in the actual sound production of a performance' (2006, p.2). Although this idea may be valid, it does not include the multi-modal functionality of gestures. As a musician, a large percentage of my performative practice comes from interpreting through-notated scores, and I believe that gestures are identified and analysed not only by communicative intention, but also by physical functionality and theoretical construction of gestural musical cells. This can clearly be seen, for example, in the opening of the "figure-8" sequence of the d-minor *Sarabande* of J. S. Bach's Cello Suites.[9] The semiotic idea that Gritten argues deals more directly with a combination of functional and communicative intent within a musical text. In finding avenues for analysis of musical material to draw from, for the research, a division of musical, physical, and later expressive gestures needed to be devised. My investigation of gesture deals with communicative intent, but does not rely solely on it for artistic and personal verification.[10] The research is grounded within the following multi-modal functions of gestures as outlined by Claude Cadoz (1994) :

- Ergotic — material action, modification and transformation of the environment;

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[9] The figure-8 sequence is one that was used as a case study (discussed further in detail later in this portfolio). In short, the referenced sequence outlines the chordal progression of I-IV-V in the first two bars, but in the B section we begin with a V-I sequence that is both stretched with a blocked hand position. Bach adds passing tones that lead back to the chord of importance, but this could also be seen as an embellishment in the current key.

[10] Although my research deals with communicative intention, it is not meant to focus completely on subjective reflections or on the perspective of the spectator. It looks at both. By understanding the dynamic of the subjective form, it enhances the form that is communicated to the audience.

- Epistemic — perception of the environment;
- Semiotic — communication of information towards the environment.

The ergotic function focuses directly on the analysis on the movements of singular/collective body parts such as arms, hands, feet, their direct contact with the cello, as well as their isolated function without an instrument. Throughout the thesis, I reference this function with the labels **instrumental** gesture (directly related to performance with an instrument to create sound), **ancillary** gesture(body movements associated with instrumental gestures though not always visibly seen) and **physicality (**movement related to a performative state). Instrumental and ancillary gestures have also been referenced as 'effective and accompanist gesture' by François Delalande in a study on the playing techniques of Glenn Gould (Delalande, 1988). Regardless of a choice of labelling, the aim is to investigate sound/non-sound producing movement associated with the relationship between human-instrument interaction.

The epistemic function focuses directly on a tactile-kinaesthetic perception and movement. As a cellist, I use tactility to assist in understanding weight (emphasis and distribution), speed (through full or isolated body parts), as well touch and 'muscular/articulatory sensitivity' (Cadoz, 1994, p. 78). Later in the thesis I present movement case studies that investigate subjective and inter-subjective reflections/relationships on how I move and articulate my body in both solo and ensemble dance settings, as well as instrumental performance with and without wearable technologies. The epistemic function is usually always related to ergotic as they support one another through action and feedback loops to help better understand the mechanics and intention of communicating gestures in music as well as in dance.

The semiotic function looks specifically at how the design and function of gestures in musical notation promotes sound. The complex nature of notation, whether musical or physical, affords a performer the almost impossible opportunity of translating

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a composers vision into something both visual and sonorous. In using the semiotic function, the analytical goal of the research was to look at the written score from a subjective point of view and gather both qualitative and quantitative data from the musical material that would help heighten the performer's understanding of movement and ways to communicate the notated material. The performer's use of the notation is what Cadoz refers to as the 'communication of information towards the environment.' The specified symbols and directions help structure and outline the space or environment that the performer will eventually fill with sound. In dissecting whole or parts of a score, new possibilities arise for communicating the scored movements which choreographer, William Forsythe refers to as *'identities.'* Identities are tools used to assist in expressing an idea. The identities from the works analysed in this thesis are then linked together as gestural patterns. Many times the patterns and identities overlap with a goal of possibly strengthening the output.

It is worth mentioning that although the three gestural functions have been outlined independently, they rarely function as such. Clear examples presented later in the thesis will show the interconnectivity of independent identities within one type of gesture.

1.3 PERFORMATIVE IDENTITIES

In an interview from 2006, choreographer, William Forsythe, speaks with interdisciplinary artist Thierry de Mey about the creation of Forsythe's work *One Flat Thing (*2000). In speaking about genealogies of movement, patterns and identities, he references writer Francis Spufford's exploration to the South Pole as a 'baroque machinery.' Forsythe discovered Spufford's writing while gathering inspiration to remount his work *One Flat Thing* by reading the book, *I May Be Some Time* (Spufford, 2003). Forsythe's focus on how the Poles have been perceived, dreamt of and even

desired leads to the theme of 'baroque machinery' as it relates to identities, and the dissection of physical perceptions.

Spufford described a 'baroque machinery' as a situation that depicts sailors' feelings about the antipodes. Through that situation they could entrain themselves within it and learn to survive. So, in recounting this idea, Forsythe surmises that the main principle behind this experience of entrainment is counterpoint, as it relates to classicism.[11] From classicism, comes the idea of polyphony based on alignments and symmetries, which affords the possibility of identifying varying degrees of similar or contrasting identities within them. In the world of dance or movement analysis, the goal on a theoretical level is to see the identities as tools to create forms and patterns. In doing this, multi-modular levels of gestures as outlined above can be separated as well as connected. Forsythe states that as we move away from observing and depicting the likeliness of symmetry and alignment, we are then asked to scan more and acknowledge segmented interactions of identities and tools involved in the larger arc of the counterpoint (de Mey, 2006). Later in the thesis I present segmentations and taxonomies of identities in gestures, and draw conclusions about the intention of the music, as well as clearly map out phrase structures that were likened to poetic metering. The outcome of this work helps to further strengthen the goal of using the body as a membrane through which expression and gesture are given a place to resound.

1.4 AFFORDANCES

The word 'affordance' was invented by perceptual psychologist J. J. Gibson in 1979 to 'refer to the actionable properties between the world and an actor (a person or animal)' (Gibson, 1979, p. 2). To Gibson, affordances are a part of nature, and do not have to be visible, known, or even desirable. According to Gibson, affordances should furthermore

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[11] Creating sets of rules that allow for parallel or contrasting events to occur. Forsythe uses this idea to develop segmented patterns in the choreography that groupings of dancers quote one after the other. Upon close look, you are then able to observe the holding and unfolding of each utterance.

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not be dependent on culture or even prior expectations, but constructed from actionable possibilities, whether they be physical or visual. However, affordances in the world of design determine what actions are possible by projection. The best possible usage and measurement of success of an affordance is heightened by adding well thought-out mapping and feedback such as an elevator button with carefully placed directional signage and illumination on the button to show feedback of correctly executing the action. In regard to music and sound, I investigated the relevance of affordances in performance such as instrumental gestures and sonorous results and in musical scores, where the design of compositional ideas allow sound to invite action and vice versa. In looking at affordances in musical settings, the researcher can face problems that are related to cultural associations, physical performance practices, musical sound sources and cultural association of what is sound. With such complexities already present, I needed to find new ways of exploring the music purely through gestural sonorous agents that can still be traced to the compositional scores.

To clarify the concept of affordances further, I present a door knob analogy to help better present the relationship of affordance and feedback. If a user tries to enter a building and is presented with a door knob, he must decide whether to: a) push, b) pull, c) turn it, or d) twist and pull it. Those actions are sequential affordances and one attempt leads to another. The combination of trying, getting feedback and being aware of the correct result allows the user to better understand the function of the object from attempting the action. All the attempted combinations will have a different result, but the user must try a few before finding the final use of the affordant movement or object which will corroborate the action for gaining access to the building and acknowledge how the object is to be used.

This section focuses on Perceived Affordances, which are independent, and allow for a connection to be made to the work in discussion. With regard to the research, I am

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searching for perceivable actions that clearly define the work in question. In the Allemande movements of J. S. Bach's Six Cello Suites, for example, Bach consistently writes a sixteenth anacrusis before each full bar. This highlights both a dominant to root harmonic progression, as well as a physical leap, both musical and choreographic, needed to close the previous Prelude movements and showcases the disjunct physicality needed to outline the new harmony.[12] The important affordance here is the consistent anacrusis which caters to more than just the harmonic structure, but also to the choreography of the performer. For many, the angle at which they perceive the 'important' affordances of the idea will differ, and 'this is precisely what makes music irreplaceable, and interchangeable with no other form of expression' (Chion, 1983, p. 1). By acknowledging the distinct properties that are needed to perform the work, either physical or sonorous, I am able to better understand the intention of the composer and my relationship to the work.

Adding features or extensions to the music can also help one engage more with the music. These extensions are types of physical or sonorous feedbacks that corroborate the action performed. Feedback, as cognitive engineer Donald A. Norman states (Norman, 2013), can help with understanding and validating the action, but is independent of the affordances. Feedback serves as a signifier of the results of an action just taken place, for instance the illumination of WAIT when pressing the button at a cross-walk intersection. On the surface level, I have looked at a multitude of musical scores or conceptual models that are used to construct music and art, and each has a formula or language that needs explanation for its function and usability. It takes, as argued by Norman, Feedback and a clear path of deciphering and extra instruction to extract and comprehend the hidden affordances.

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12 This sixteenth anacrusis also affects the way in which I use my body to prepare the introduction of the new movement. The engagement of muscular dexterity and focus of energy trajectory is ever present.

In my research I extracted and analysed affordance case-study materials with Labanotation (Barbacci, 2002) and the Qualysis Motion Capture system (Takasaki, 2011). I searched to find movement that stood-out as a singular action that either was developed or 'unboxed' over the course of the piece. In some instances, either the physical gesture or a strand of the initial movement kept resurfacing or was traced to a design model in the work. In other instances, I was confused about the movement needed to create the specified action, due to a lack of clarity from the notated symbol in the score, as well as my role in performing the piece. This is clearly seen in Lachenmann's *Pression* in both 1969/70 and 2010 versions of the score. There were confusions in hand position, discrepancy in fingers used for certain actions, as well as clarity in explaining actions notated. These were later clarified in the 2010 version through extensive work with Lucas Fels; although this version may represent more of Fels' interpretation.

Situated within Lachenmann's musique-concrète instrumentale, the initial statement in the choreography and notated score continuously resurfaces throughout *Pression*. He introduces the first phrase in the form of a long static line that is then interrupted through swift scraps along the cello strings. This phrase is a practice on creating interference within fluidity.[13] The phrase is then further developed through the addition of multiple 'stuttered' scrapes along the strings; switching annotated strings to change the colour, timbre and effort used; as well as creating short, choked utterances from the bow. With these changes, Lachenmann shows different variations not only in the reactionary sound, but also in the choreographic patterns. The cellist's goal is not only to successfully reach a sound goal, but to navigate a connection between the expressive actions of both the left and right hands for the first phrase autonomously. In doing this, the cellist develops smaller actions within the larger to create a fluid and

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[13] The difficulty in performing the opening theme is creating a smooth stagnated line of noise over the bridge and then interjecting the left had nail scrape as if interrupting someone's peaceful sleep.

successful initial gesture. Without the affordances being built into the design, the extended techniques of the left hand and the rigid but flexible wrist in the right hand, the piece fails to function successfully due to its mostly perceivable action-based structure.

1.5 SHIFTING

In the above section I mentioned the idea of the affordances in a work and how an affordant property connects its user to an actionable goals. For the musician, that could be physical movements, analysing harmonic patterns, or analysing one's own instrument, which is linked with cultural associations in its performance practice. Using Lachenmann's *Pression* once more as an example, it would be the cello. Given that the work is written exclusively for the cello, this does not mean that every cellist comprehends the actions in exactly the same way. Every musician (user) will have similar initial approaches, mostly based on pedagogical dissemination, but through learning it, they find personal affordant actions that help them translate and shape the physical and musical ideas.

I have found specific affordances that help me to understand the piece and interpret the work as I see fit.These are not completely subjective models, but tactile and visual examples that give a different perspective regarding the design and eventual dissemination of the work. What is interesting, however, are the treatments of these affordances over the course of the work. The gestures within a piece like *Pression* might be performed the same way sonically or not based on movement and intention, but the affordant action chosen to engage movement with the score is the focal part. Out of the movement comes the sound, so the choreography must be explored further to understand this conceptual approach.

1.6 SOUND TRACING

Having been given a sonic stimulus of abstract sound, the audience creates a visual translation that closely replicates what they are hearing from an embodied or perceptual perspective.[14] The sound is primary and the gesture is secondary. This is the opposite of "musique-concrète instrumentale," but still a valid way to understand and approach expressive gestures and embodied sonic interaction. Lachenmann states in an interview:

> The original musique concrète, as developed by Pierre Schaeffer and Pierre Henry, uses life's everyday noises or sounds, recorded and put together by collage. I tried to apply this way of thinking, not with the sounds of daily life, but with our instrumental potentialities… I am working with the energetic aspect of sounds. The pizzicato note C is not only a consonant event in C major or a dissonant event in C-flat major. It might be a string with a certain tension being lifted and struck against the fingerboard. I hear this as an energetic process. This way of perception is normal in everyday life. If I hear two cars crashing—each against the other—I hear maybe some rhythms or some frequencies, but I do not say 'Oh, what interesting sounds!' I say, What happened?' The aspect of observing an acoustic event from the perspective of 'What happened?', this is what I call *musique concrète instrumentale* (Lachenmann, 2008).

In my work on the embodiment of movement and sound, my approach is similar to Lachenmann's theory of *musique concrète instrumentale* . Having chosen works that I knew quite well, part of the analysis and investigative process was to further understand the intention behind the movement that yields a physicalised sound. The case studies chosen were from different musical genres, sonic worlds and notational styles.[15] I found myself mimicking, for example air-guitar, sound just as the participants in Caramiaux's research had done as a way to locate connections between actual physical movement and the resultant action heard within the sound. In contrast, tests were also done to

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[14] See Baptiste Caramiaux's research on Gesture-Sound relationships: B.Caramiaux, F. Bevilacqua, and N. Schnell. *"Towards a Gesture-Sound Cross Modal Analysis"*.Lecture Notes in Computer Science, Embodied Communication and Human-Computer Interaction. 5934, 2010, pp.158-170; and Andrew Lewis and Xenia Pestova's research on Sounding gesture in 'mixed' music for piano and electronics, 2012.

[15] The selected musical examples were chosen to create a broad variation to the musical scope in regard to performance practice and variances in physical effort needed in performing them.

locate or describe plausible sounds based on isolated movement. The mimicking of embodied movement allowed me to slowly mould the core intention of the gesture, its meaning to me and how that ultimately relates back to the score. It was an enlightening experience given the fact that many times as musicians or creators, we neglect our personal reflective process in regard to technique or phrase development. Many times, physical and structural creation is done on a subconscious level without stopping to address hierarchy between the physical and sonic output because the act of doing has become second-nature. The forthcoming chapters give further insight to the unpacking and transforming of affordant and gestural material.

Basically one has to start with the description of movement, and occasionally mention single space forms, for transformations, and their laws. Our aim is thus the mastery of movement through its explanation (Laban, 1920, p. 2).

CHAPTER TWO

Rudolf Laban and Theories of Choreutics and Eukinetics

My interest in movement, indirectly focused on musicians, but also people as subjective entities, came from experiences in performing (solo and chamber music), injuries my colleagues suffered from improper use of the body, as well as an interest in linking decoupled physical movements in performance with that of rudimentary motor skills. Through continuous observation of my own practice and that of my colleagues, coupled with productions that involved close collaboration with dancers, a realisation that there was a serious lack in the understanding of the mobile body (singularly) in regard to instrumentalists became even more evident. Since then, I have worked to uncover ways to examine the mobile body in performance and pedagogy while applying notions of embodiment, affordances and expressivity. I chose to use a portion of Laban's body of work as inspiration for my research as it was the best fit in regard to the analysis of "bodily scripting" and instrumental music gestures, and when speaking of guided movement, mapping strategies, force, space, and energy, Laban's approach was the most sound choice.

This chapter focuses on examining Rudolf Laban's kinaesthetic movement theories of Choreutics and Eukinetics and in later chapters, draws connections to personal performance practices in works from the solo cello canon. A brief background overview precedes a discussion of Laban's theories and practices of Choreutics and Eukinetics, breaking down the main kinaesthetic theory, Choreutics (Space Theory) and its counterpart, Eukinetics (Effort Theory). This area of research and development in movement has remained instrumental for dancers, educators and choreographers, and it

is my intention to also show its relevant significance for instrumental performance. In short, the focus is to heighten the understanding of what the singular body is capable of when separated from a musical instrument.

2.1 CHOREUTICS AND EUKINETICS

The dance design can be analysed by means of choreology from the point of view of the dynamism of spatial directions building characteristic forms of design...Dance structures can convey clearly to the viewer an inner experience and development of an inner drive which is anchored in a universal human experience (Laban,1927).

Rudolf [von] Laban, famed movement theorist, dancer, and choreographer, is regarded as a recent visionary in the exploration of theory and practice of dance and movement of the 20th Century. Born December 15, 1879 in Hungary, he was the son of a high ranking military officer who travelled widely, tried and rejected the military as a career, and eventually undertook formal training in art and architecture.[16] Early childhood and adult experiences from growing up in the Austro-Hungarian Empire, Paris and Germany, would prove fruitful to his understanding of music, art, the moving body and eventually facilitate in the development of his dance notation. With a career that spanned from the early 1920s until his death in 1958, he helped to transform dance as an art form as well as reform the role and aesthetic of dance education. This was achieved in part by developing dance theories, methodologies and his invented system of dance notation, now known as Labanotation or Kinetography Laban (which is inspired by the work of Laban's predecessors Beauchamp and Fenillet around 1700). Laban's main goal was not to rewrite the world of dance to his liking, but to free it from institutionalised constraints of traditional steps, a reliance on music to find inspiration and structure,

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[16]   For information Laban's life and work, see Hodgson and Valerie Preston Dunlop, *Rudolf Laban: An Introduction to His Life and Work* (Plymouth, UK: Northcote House, 1990).

and finally step out on its own and revel in the body that is free to move purposefully and intently in any medium of space. It was in the period of the early 1920s that Laban helped initiate the birth of Der Freier Tanz (The Free Dance).

In his first English text, *Choreutics,*[17] written in 1939, Laban explains that Choreutics is 'the practical study of the various forms of (more or less) harmonised movement' (p. viii). In this book, he explains that the body is positioned in space through multi-dimensions, planes, and geometric forms. Laban codified these movement pathways into what we can think of as "scales," that allowed for there to be a full three-dimensional movement sequence around the body's core. Just as there exist scales in music that need to be practised with precise attention to intervallic distance and placement, these movement scales cover specific points at "fixed" distances away from the body's core (from which all movement evolves) and must be practised and mastered. These theories and analyses are especially important not only in dance theories, but also in the analysis of choreographic gestures in instrumental music.[18] To put this into perspective, the main state of stability is rooted not only from the core of the instrumentalists body, but the feet, head and arms. Examining these movement shapes, or *trace-forms* as quoted by Laban, movement patterns can be seen that bind and intersect with each other. Through the guidance of Laban's *Choreutics* analysis, I looked at the basic core form of movement happening and created a taxonomy of instrumental and ancillary (secondary) gestures associated with the moving body and the music. This, as seen on a triptych level, shows a three-dimensional perspective of the moving body on its own and with the instrument; further allowing one to understand what is

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[17] An English edition of Choreutics, which was originally written in 1939, was published by Macdonald & Evans in London in 1966, with notes and additional text by Laban's longtime collaborator in England, Lisa Ullmann. Under the title *The Language of Movement: A Guidebook to Choreutics* this work was published by Plays, Inc, of Boston, in 1974. It is from the 1966 edition that references in this paper are made.

[18] That is in regard to somatic patterns in the practice of instrumental performance. As well, these mappings of events or gestures in instrumental music could be used for pedagogical or performance notation.

instrumental guided movement and personal. Since the cellist, for example, is seated in normal cases, I have chosen to slightly disregard the lower level and adapt it to fit my performative state. Later in the thesis, I will show Motion Capture sessions which highlight and heighten Laban's idea of Space Harmony in regard to *trace-forms*.[19]

Though Laban's theories of Space and Effort are truncated into two separate areas, they are seen as one and the same, and without one the other can not exist, but they both fuel each other (Cf. "Advaya").[20] Space (Harmony), or *Choreutics*, is the form from which movement is able to sprout (while having a *stance* or base) and Effort, *Eukinetics,* is the expressive agent by which form operates within. Put simply, Effort measures the quality of the movement and is categorised under what Laban calls the *Dynamosphere*. 'All that we perceive through our eyes consists of objects or movements arranged in space. So it is with our aural perception, or hearing. Sounds are spatial arrangements, vibrations or oscillations, and they fade from our ears in the same way that visible movements vanish before our eyes. We can see different movements or hear different sounds at the same time' (Laban,1966, p.28). My aim is to take a deeper look into what the larger formulated movements are which I have chosen in order to execute notated music or improvisations. There's no sense in arguing that these movements are fleeting states, and it is almost impossible to dissect each minuscule movement due to the fact that most large gestural movements are composed of 6 or more sub-movements. Laban devised the system of Space-Effort that allows the user to focus either on large visual movements (peaks), smaller ones (transitory), or a combination of the two. Laban states in his book, 'A movement makes sense only if it progresses organically and this means that phases which follow each other in a natural succession

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[19] Space Harmony is another way of saying Choreutics. In the early stages of Laban's work, before Choreutics was finally named, he referred to this movement theory and practice as Space Harmony.

[20] Advaya in Sanskrit in its literal translation means "not two without a second," as well as non-duality. A connection is drawn to show that both elements of Laban's theory of Space and Effort are one entity. Though they have their own main focuses, they never stand alone, but are used as one force for movement and expression.

must be chosen' (1966, p.4). Mostly this theory holds, but concerning improvisations, these successive movements may not always coincide in a neat and orderly package, just as we have with musical scales. In using Labanotation, I have tried to piece together distinct movements that either borrow from or are linked directly or indirectly to "organic" physical progressions. Discussing the relationships and unity of space-direction, time-duration, and force-energy, he argues that the division of a gesture into space, time, and force is only an apparent one.[21] Fundamentally one cannot imagine any of these three concepts without the other (Laban, 1920), p.54).

Below I have included the basic overview of the Principles of Laban's notation and his Space and Effort concepts are seen within the 1926 outline of the "Elements of Form Theory":

a) Bodily participation from the point of view of laterality and symmetry;
b) Spatial-directional participation determined by the angle of deflection from the vertical;
c) The shape of the moving body in space with regard to the three dimensional distribution of the body mass in relation to the verticality, sideways, backwards and forwards (or its plasticity). It can be predominantly stable, promoting equilibrium, or labile, promoting movement, such as fall, thrust, swing.[22]
d) Constituent parts of form seen as a temporal sequence with a beginning, middle, and end.

The movement form *Eukinetics (Effort)* is characterised by:

e) Kinetic content (degree of lability) referring to flux or flow[23]
f) Dynamic content (degree of tension) referring to force
g) Rhythmic contact (degree of velocity, speed) referring to time
h) Metric content (degree of extension) referring to space

From these divisions of movement in regard to the Space and Effort outline above, it can be seen that Laban has created a clear framework in which to dissect the moving body from its multi-dimensional structure and expressive functionality. Although these

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[21] The idea of gesture of course is a heavily debated topic, but I translate this as movements easily recognisable by their spatial appearance and transitory positions, which are movements connected to the larger descriptive peaks.

[22] This can be directly associated with sound and silence. There are instances where we feel the music as it is, has stopped or has yet to begin, but in theory, the energy/movement is still occurring.

[23] Stagnation or promotion of movement.

bulleted points explain individual identities of movements, they inherently function together from beginning to end. In the next chapter these concepts are truncated into Laban's *Eight Basic Efforts* and used to assist in deciphering my conceptual understandings of movement in a series of case studies on compositional works for solo cello. The aim is to adapt Laban's kinaesthetic theories to allow for a more sound approach in perceiving and measuring the subjective corporeal movement of the musician alone and with his/her instrument.
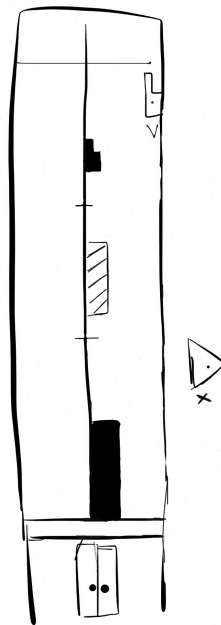

Fig. 1: Freehand Labanotation Sketch of movement from PNOM by Claudio Gabriele to show a two-beat metered movement sequence that includes a range of force and contractions in the body (represented by the "x"), and separated dimensionality of one singular motion.

CHAPTER THREE
Case Study Examinations

The next sections put the principles of Space and Effort into practice by looking at case study materials from Johann Sebastian Bach's *Six Cello Suites*, Helmut Lachenmann's *Pression,* Edward Hamel's *Grey Neon Life*, and Claudio Gabriele's *PNOM*, demonstrating comparisons between Space – Effort, and Prescriptive and Descriptive notations. The compositional styles of Gabriele and Hamel, both successful in disseminating musical ideas,[24] are juxtaposed against Laban's theories to try and gain further insight into the musician's analysis of performing music. I've chosen this approach because descriptive/ prescriptive words still lack in bridging the gap between action and intent. So, by attempting to use these three notational systems (Prescriptive, Descriptive and Labanotation) I strive to come a little closer to understanding the instrumentalist's perspective in deciphering, understanding and performing musical works; regardless of their direct or abstract nature.[25]

In this chapter I address the intersection of technical, analytical, and artistic approaches in perceiving and measuring movement from the cello music canon. The question of the state, potential, and methodological limitations of movement analysis is presented here from the perspective of practice-led musical research. This inquiry stems from a long-term examination and experience with movement-based, electronic-assisted, and embodied interaction in performance. In particular, the focus is put on the methods and resulting insights — obtained from measuring aspects of body movements

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[24] Gabriele's use of tone rows in the first movement are later retrograded in the third and fourth movements. The reappearance of the first theme is later fragmented by showing only trace segmentations. Hamel uses a 'morse code' clicking devise in the very opening of the work. This same idea continuously serves as a divisional tool between the quick and rapid gestural-lined sections, a notational tool he uses that does not include specified pitch material but dictates spatial movement examples. The clicking is seen as a binding tool that bookends the composition together.

[25] The point is not to show that one notational style is more or less valid, but to use them together for the sake of analysis to show connections of movement without bias towards genre or style.

of the performing musician. Technological tools, conceptual approaches, dance theory notations and models used in several of the studies help shed light on the limitations of historical analysis of movement of musicians.[26] The dance world in contrast has a rich and fruitful scholarship on the analysis, archiving and dissemination of performance for artists, and the aim is to further the in-depth scholarship for instrumentalists — in this case, cellists. The studies presented here borrow from a broad range of technical tools due to of the lack of a general methodology for movement analysis for musicians — outside of technical etude books or personal performance practice treatises. As previously stated, this research was never meant to replace current instrumental practices — regardless of geographic and pedagogical practices. The technical findings presented are a singular approach, aided by informative practices by Dourish, Godøy, Jensenius, and Wanderley, respectively.[27]

3.1 CONTEXT

Investigations into methods of research that are effective for movement in music performance through psychological, qualitative and quantitative analysis have become a research area that has produced highly usable results (see Bevilacqua 2007/2011,

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[26] In mentioning the limitations of historical analysis, I do not mean to discredit the work of the past, but to state that this approach serves as a subjective analysis from the performers perspective. Scholarly work even by acclaimed scholar, Jane Davidson, uses a slightly objective approach in analysing bodily gestures of solo musicians and the kinds of movements that observers/listeners perceive. Examples of this work can be found here:
Davidson, J. W. (1994) What type of information is conveyed in the body movements of a solo musician performer? Journal of Human Movement Studies, 6, 279-301;
Davidson, J. W. (2002) Understanding the expressive movement s of a solo pianist. *Deutsche Jahresbuch fur Musikpsychologie,* 16, 9-31.

[27] Writings of the researchers practices may be found here:
Dourish, O. (1999). Embodied interaction: Exploring the foundations of a new approach to hci. *Unpublished paper, on-line:* http://www. ics. uci. edu/~ jpd/publications/misc/embodied.pdf
Godøy, R.I., Haga, E., and Jensenius, A.R. Exploring Music-related Gestures by Sound-Tracing — A Preliminary Study. In *Proceeding of the COST287-ConGAS 2nd International Symposium on Gesture Interfaces for Multimedia Systems* (Leeds, 2006), 27-33.
Jensenius, A.R., Kvifte, T., and Godøy, R. I. Towards a Gesture Description Interchange Format. In *Proceedings of the 2006 Conference on New Interfaces for Musical Expression,* NIME '06, IRCAM Centre Pompidou (Paris, France, 2006), 176-179.
Wanderley, M. M. , Vines, B. W. , Middleton, N., McKay, C., and Hatch, W. The musical significance of clarinetists' ancillary gestures: An exploration of the field. *Journal of New Music Research 34,* 1 (2005), 97-113.

Hattwick and Woods 2014, Nymoen 2013, and Orning 2013). In addition to these mapping and structural data tools are the elements of interrelationship of embodiment and sensorimotor, which is an interesting, and hard to define state of resonance in performing, observing and listening. Further cross-disciplinary methods have surfaced in the work of William Forsythe (Synchronous Objects) and Emio Greco (Intention) and Wayne McGregor (R-research). The implications of these outputs is best summed up by Johnson:

> 'Music exists at the intersection of organised sounds with our sensorimotor apparatus, our bodies, our brains, our cultural values and practices, music-historical conventions, our prior experiences, and a host of other social and cultural factors. Consequently, musical motion is really experienced by us, albeit via imaginative structuring of sounds'(Johnson, 2007, p. 255).

 Within musical perception, 'the processes we are affected by, perceive and act out are dynamic chains, i.e. streams of sound-objects as well as action/sound pairs or multi-modal "gestural sonorous objects"' (Schacher, 2015, p. 132). The state of intrinsically individual performance finally contains more social, scientific and psychological grounding that allows for further scholarship to be added in the coming years that sits outside that of cognitivist research.

3.2 MOVEMENT MEASUREMENT

Before delving directly into findings of the movement analysis from the studies conducted, let us discuss the possible ways in which music is perceived and can be measured. As stated previously, the analysis was built directly on multiple strands of empirical processes and findings, and designed to bring together different techniques that allow us to understand the instrumentalist's body movement on a more in-depth level. Of late, current pedagogical research has shown little output in the integration of

Laban .[28] In the case of Almost Human, I adopted some of Laban's 8 Basic efforts, and supported them with Motion Capture data, as well as rudimentary qualitative findings from live performances. Without relying heavily on qualitative findings, the sound recordings of MoCap sessions were also analysed to add layered variance to visual representations. Prescriptive notations are discussed and unboxed to highlight and show variance in the translation of musical score to physical and sonic realisation.

When we as observers listen to music either privately or in live performance situations, there is a multi-modal hierarchy or perception and understanding happening. In observing, we notice the performer's facial expressions and dynamic actions (plucking, pizzicato, speaking, singing, scrapping, stomping, and sometimes mental/physical exhaustion), but how can we measure the elements that aren't so perceivable to the not so distant naked eye? These same implications apply to performers on a subjective level on an action-perception feedback loop. The elements I am suggesting are expressive and ancillary gestures, and to date, can only be quantitively analysed by technological tools. Instrumental gestures on the other hand, can clearly be identified, as they are the movements which both performers and observers associate with action-sound production. Researcher, Jan Schacher suggests,

> 'These sound-actions produce body movements in the case of instrumentalists, in the case of singers at least produce traces in the body and the face. Measuring these movements can occur through several perspectives, in relation to the egocentric space, for example; the points of view or the reference systems can be categorised as out-side-in, inside-out or inside-in' (2015, p.2).

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[28] Few research outputs have produced scholarship that combines all the areas I use to discover new information that isn't singularly conceptual, qualitative, or quantitative in output. Recent examples of singular scholarship can be found in:
Donald, E. (2009). "Balance & Bowing: Investigating the Effects of Tempo on Bowing and Torso Movements in Expert Cello Playing" *McGill University Music Graduate Students' Symposium*, Montreal.
Hadjakos, A. (2011). "Sensor-based feedback for piano pedagogy," Ph.D. dissertation, TU Darmstadt;
Palmer, C., Koopmans, E., Carter, C., Loher, J. D., and Wanderley, M. (2009). Synchronisation of motion and timing in clarinet performance. *International Symposium of Performance Science*, 159-164;
Verrel, J., Woollacott, M., & Lindenberger, U. (2014). Articulated coordination of the right arm underlies control of bow parameters and quick bow reversals in skilled cello bowing. *Frontiers in Psychology, 5*, 885.

Further studies that align close to this are those dealing with the sonic miming (aka "air-guitar") to determine physical associations to intention, space, and cognitive embodiment.[29]

Leman and Camurri argue that 'The notion of corporeal imitation thus offers an understanding of the relationship between the mental involvement with music and sound energy. Corporeal imitation can be seen as a mediating process that relates mental processing to physical energy' (Leman & Camurri, 2006, p. 209). The notion of corporeal imitation or miming is one that was implemented heavily in the association and clarification stages of expressive gestures throughout the studies, and juxtaposed against prescriptive notations and quantitative data to help further support the multi-methodological approach in this research.

3.3 THE PRESSION STUDY

Helmut Lachenmann's groundbreaking work, *Pression* (1969) lies at the forefront of experimental works for solo cello. The critical question this study focuses on is how to understand it — not as a (self)-contained work, but as a living object, as a performance and the actions and embodiment within. *Pression* was one of the first works to introduce Lachenmann's concept of *musique concrète instrumentale* — music that allows you to 'hear the conditions under which a sound-or noise-action is carried out, you hear what materials and energies are involved and what resistance is encountered,' which completely switches historical hierarchies (Lachenmann, 2008). After my initial analysis of the work was completed, I met researcher and musician, Jan Schacher in Zurich, and alerted me to the fact that he, along with Alexander Jensenius, had also done MoCap

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[29] Examples of these studies may be found here:
Caramiaux,B., Bevilacqua, F., and Schnell, N. (2010). Towards a Gesture-Sound Cross-Modal Analysis. *Lecture Notes in Computer Science, Embodied Communication and Human-Computer Interaction.* 5934, 158-170.
Caramiaux, B., Bevilacqua, F., and Schnell, N. (2010). Mimicking Sound with Gesture as Interaction Paradigm. IRCAM — Centre Pompidou. Technical Report.

research on *Pression*. Their work looks at the composition from very different strands, but nonetheless uses many of the same techniques for capturing data. Schacher, who used the Optitrack motion capture system (See Figure 2), looked at multimodal strands of information to better understand intention, cognitive perceptions, physical constraints, as well as sonic and visual representations of the performer and performance of the piece. Jensenius, like I, used the Qualysis Motion Capture system (See Figure 3), which I find to be much more accurate in regard to data retrieval and consistency in skeletal structure composition and data scrubbing. Jensenius' study was used for a collaboration between cellist Tanja Orning and composer Natasha Barrett, and recorded at fourM's Lab[30] in Oslo (See Figure 4), with the goal of gathering data from Lachenmann's *Pression* to eventually be used for 'sound and spatial transformations where sound and data originated from one and the same performance gesture' (Schacher, 2015, p. 3).
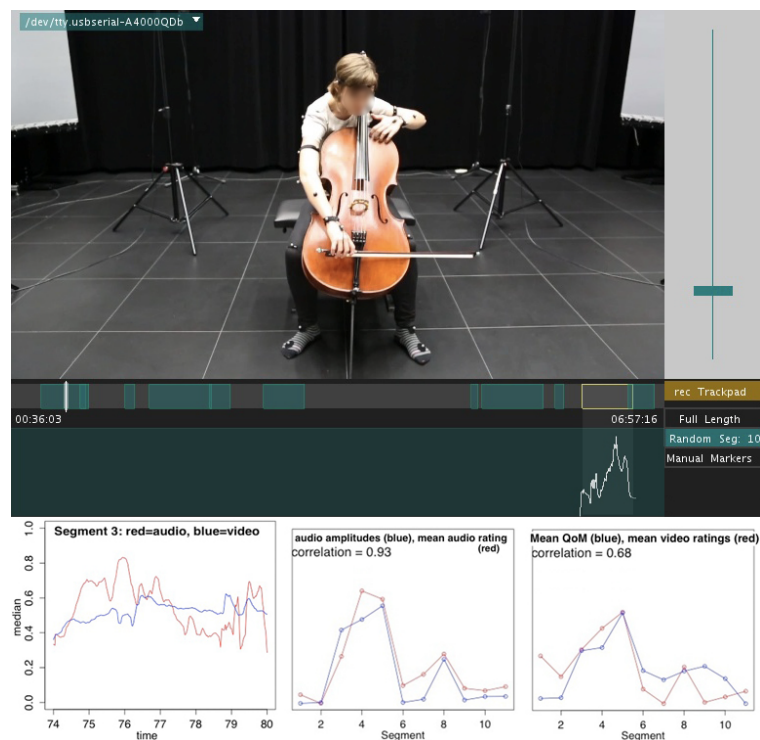
Figure 2. Qualitative video-survey tool used to investigate Lachenmann's 'Pression' for cello solo and plots of preliminary results (Ellen Fallowfield, cello, and images by Jan Schacher)

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[30] Further information on the fourM's Lab may be found here: http://www.uio.no/english/research/groups/fourms
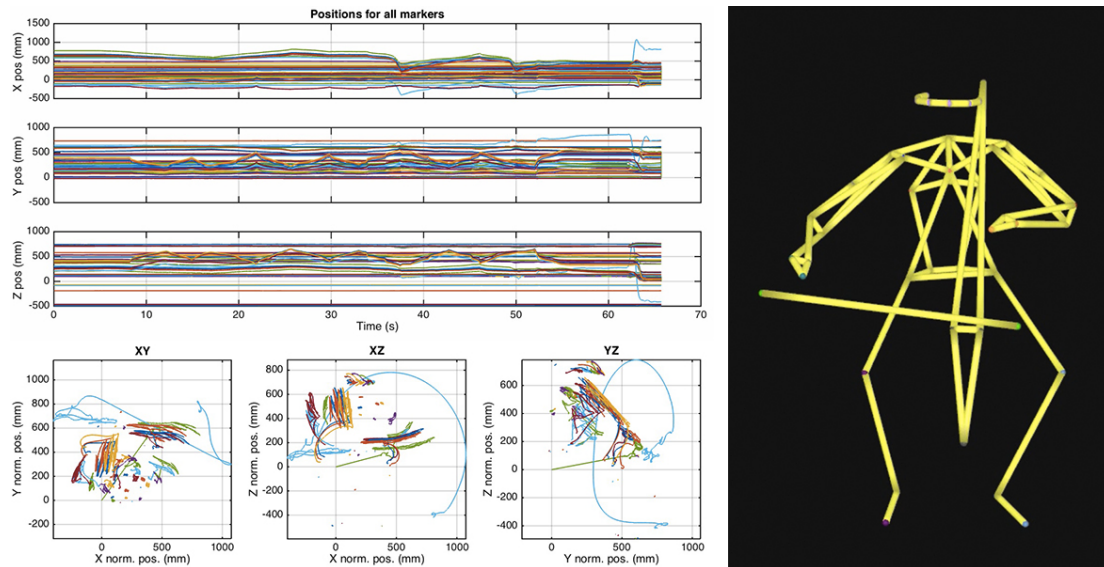
Figure 3: 'Pression' MoCap of Seth Woods plotted over time and in space, and as 3D visualisation (plots by Alexander Refsum Jensenius).
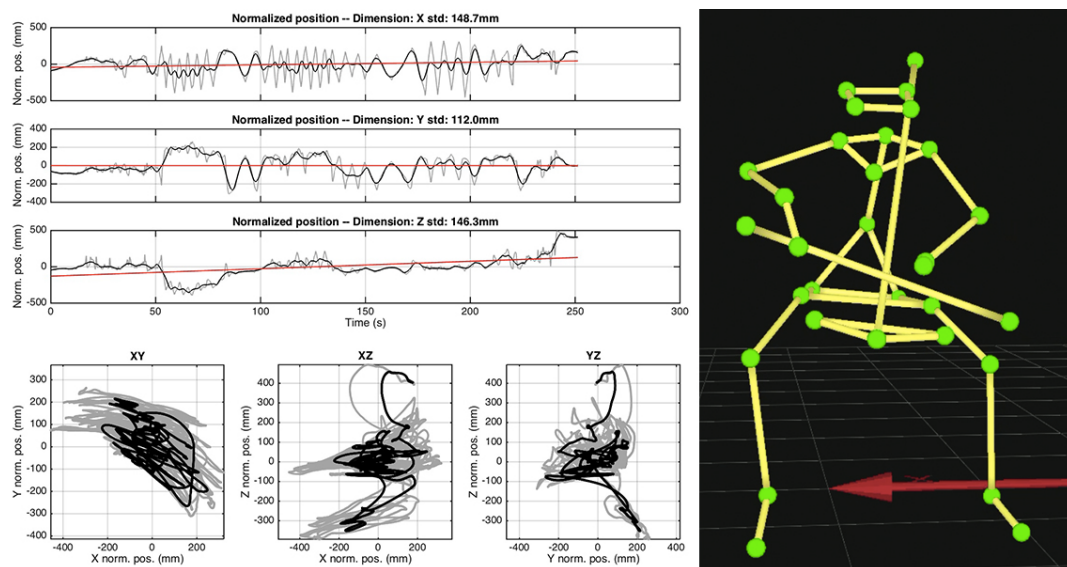
Figure 4: 'Pression' MoCap-data of Tanja Orning's right hand plotted over time and in space, and as 3D visualisation (plots and image by Alexander Refsum Jensenius).

The study focuses exclusively on the opening material on the first page, due to a realisation that the opening material, mainly in the left hand, are gestural affordances that lay the ground work for all subsequent material. 'I was searching for movements that in the end had an affordance to the entire piece. So if I could "nail down" (identify) specific identities, evolving patterns [typologies] would more than likely show up and I could show links between them. This was the case in *Pression*. He [Lachenmann] sets out dynamic and movement material in the first two pages that reiterates it throughout the work […] a core structure, that is both textual as well as physical (from the performer's perspective). My qualitative approach looks at data sets from head movement which shows massive [movement amplitude] gains in the Bach, but Lachenmann had very little [movement amplitude] (see MoCap video Lachenmann1). In all, I looked at trace-form lines (movement lines of the body or subject) and tried to find similarities between physical bodily shapes and score shapes in the text.'[31] This process, as personally described in an interview between myself and Schacher (2015), aligns with the MoCap and archival of movement work done by Bevilacqua and Emio Greco on mapping and dissecting functioning gestures and intention movements in Greco's choreography (Bevilacqua, 2007).

One of the first things noticed in examining the Lachenmann score was the close similarity to Labanotation (if the perspective is shifted vertically — see annotated Lachenmann score in appendix). This score (1969 version) is somewhat controversial in regard to notation (mostly amongst performers) due to lack of distinctions of hand weight, bow weight, and force. In the Laban analysis the overall arc of the first page is a stagnated flow, albeit constant throughout with moments of gestural interjections (percussive finger scrapes and hesitant whispers in the bow hand) which fold back into

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[31] Personal quotation from interview on my work. Appearing in Schacher, 2015.

the already sparse texture. In question are the connections of weight and force in both the left and right hand movements.

Right Hand

A quick scan shows the inconsistency of the action notation or prescriptive notation (as now more commonly used — Seeger 1958, and Kanno 2007) for the bowing from the beginning of the piece. In the first system, Lachenmann notates a slightly thick continuous line for the continuous bowing over the top of the bridge (*Steg* as annotated in German) which thickens to a noticeably larger size in the second and third systems. However, one is not sure if this is completely intentional, as well as its connections to dynamic volume or physical pressure to be exerted from the Right Hand. In re-annotating these moments with Laban, I used his left and right directional symbols to identify direction and then refocused the pressure so that it reflects my approach to performing the specified movement. In the second system, I included a contraction notation for my stomach, as this is the action sensation felt in performing this gesture correctly. There will more than likely be differences in performance from cellist to cellist in this section, as well as the rest of the work. The inconsistency follows through to the last system of the first page where the cellist is asked once again to produce a toneless whisper from the bow (see Lachenmann score in appendix). Seeing that the score, much like Labanotation, is a skeletal structure, still rich in expressive nuances, Lachenmann allows for a level of openness to the degree of interpretation, force and effort with which to deliver these fleeting instrumental gestures.

Left Hand

The left hand is consistently scaling the 1st, 2nd, and later 3rd strings throughout the excerpt. Lachenmann designates for there to be clearly measured jagged gestures which

fold back into the texture as soon as they have surfaced. These utterances align with what Brian Ferneyhough (1984) suggests as "immediacy of expression"— in that these "experientially isolationist tendencies" need very little explanation for their intention or expression. 'At the very moment at which the gesture aspires to rise out of its material presence it falls back into the mere historically conditioned material state, since its aspiration to uniqueness empties it of the possibility of entering the community of signifying acts as a subcategory in its own right' (Ferneyhough, 1984, p. 60). From a descriptive and design perspective, these mechanisms are cleverly used, though the performativity of them still is left a bit vague (from the performers perspective). Each gestural utterance uses the same degree of force regardless of variance in dynamic. Having personally worked with Lachenmann and cellist Lucas Fels (who the cello community attributes the 2010 revision of the score to) on the score, Lachenmann leaves some of the interpretations up to the cellist with regard to executing these gestures. The "vague-ness" or liberty with which the composer entrusts the performer is welcomed. However, for the sake of clarity and precision in the performance of a work that has now become part of the cello repertoire, I believe an appendix to the skeletal structure would be a helpful guide for cellist approaching the work for the first time. These isolated intensions, as well as the ones to follow later in the work, should be accounted for. This is not to say that every single gestural and physical action has a large motive, but my quest to find a more in-depth definition of the intention has helped clarify my association to the compositional text, as well as focus the "physical language" that I use to approach such a work.

The Motion Capture session I carried out, as well as that of Jensenius, showed similar movement amplitude traits in the way of interpretation and force given to the performing the left hand movement (see Orning Fig 4). It was then that I decided I would use those quick bursts at a later stage in the research and development of *Almost*

Human. As I stated earlier, to the naked eye, the audience normally recognises the larger physical movements which are either connected to instrumental sounds or performative flare, but through my work, the connection between ancillary and instrumental movements becomes blurred. We, as performers and spectators, shift from having a preconceived notion of what should sound and how it should resonate, to realising we can imagine/implement the "impossible". Laban provides the skeletal analysis, and the motion capture provides real time qualitative and quantitative imaginings of the text in front of us. It is in the MoCap that I found the most interesting instances of interpretation. These instances were the small and minute movements that play a larger role than they are credited for. As I continued with the subsequent case studies, it became clear that these works would be used not only as clear visualised data supplements, but would be transferred to programming, mapping, and machine learning for the work with the prosthetic Spine.

3.4 TRAJECTORY—REPETITION—EXTENSION

This section of case studies deals with smaller gestural instances in musical works by J. S. Bach, Claudio Gabriele, and Edward Hamel. From the analysis, ten gestures, derived from instrumental and ancillary movement, were chosen based on personal embodied sensations that occurred in practise. A taxonomy of these gestures are compartmentalised under: Trajectory, Repetition, and In Extension. The analysis for these gestures came from a methodology which included studying archived live performances for trace-form lines in the body, the isolated performance of musical cells, Labanotation of trace-form lines and adaptations for musical scores, and Motion Capture. With regard to Labanotation, I used Laban's *Eight Basic Efforts (EBE)* as a way to assist in the organisation of the movements from the score(s) as they pertain to my own physical language, as well as unlocking their organised performativity. Originally,

the *EBE* were created for use in everyday life both in our movement and speech. This system allows users (ordinary people and artists) to organise individual mannerisms which we tend to branch out from or heighten under extreme circumstances or emotions, i.e. anger, anxiety or anxiousness.

There is always the question of how we prefer to move in accordance with certain given or prescribed actions, but they can be altered to fit the appropriate goal at hand. For example, when using a door-knob to open a door, it would be unwise and possibly ineffective to employ the floating effort (a flying movement-light). It would be more advantageous to use a direct or strong effort for the sake of a clear, goal oriented action.The *EBE* are encapsulated by the following four categories that help shape our kinaesthetic orientation of movement: Flow, Space,Time and Weight.[32] These conceptual, but pragmatic approaches to movement help guide the overall scope of the forthcoming analysis.

Flow describes movement that is unimpeded or continuous, such as floating hair in water. It can be successive (carrying movement along), or simultaneous (one body part follows the other carrying the movement).

Space is the clear comprehension of the space or boundaries around the area in which we inhabit. As the cellist, that would be the parameters to the left, right, above and below myself—and for a centralised geography around the fingerboard—this would be between the nut (near peg box) and bridge (sometimes beyond). Laban suggests that we create certain signposts to help first determine the size of the space that we have to work with. The cellist's (traditional and non-traditional) aerial space stays the same.

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[32] The concepts of Eight Basic Efforts, which are an offspring of Choreutics and Eukinetics, were mentioned once before in Chapter 2 on Laban, but I fully explain them here for the sake of clarity in the forthcoming case studies.

Those that choose or are naturally shy due to a multitude of factors tend to cringe back and detract from the space they inhabit as a way to detract the attention from them. Laban calls this *gathering*. This is seen clearly in performers that are uncertain of the music or who possess stage freight, or who haven't explored expanding the performative level of their practice. In contrast there is also *scattering* all limbs to explore and fill the space.

Time helps us to understand and obtain the 'where' and 'when' in a situation and is done through a combination with Space. The heart of this lies within rhythm. Laban argues that 'rhythm is the lawless law which governs us all without exception. But only a few are familiar with it, although it is always around us and within us and reveals itself everywhere'. Given that the focus of the research involves music, it's hard to disassociate rhythm from music, but it simply isn't 'bound by metricality'(Newlove, 2004, p. 117).

Weight as referenced in the Dalby Newlove's book, *Laban for All,* is 'the force exerted on a body by a gravitational field…our ability to stand upright depends on the tension between the force of the body and the pull of gravity' (Newlove, p. 119). In relation to performance, we can either work with (indulge) or against (resist).

Within these four kinaesthetic categories, I use the following Efforts[33] to organise the intention and orientation of the action:

Flicking (free flow movement—light),

Wringing (flexible and sustained),

Dabbing (direct, sudden—bounces off a movement),

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[33] Having outlined all eight efforts for clarity, not all were used in the analysis process but have been highly instrumental in discerning movements that attribute to physical and gestural movement.

Punching (violent, direct movement—no indulgence),

Floating (a flying movement—light),

Slashing (floating but met with resistance eventually),

Gliding (sustained—performed with muscular tension and control), and finally,

Pressing (gravity and weight align here to cause a movement that pushed, crushes from both directions—with fluency)

Ten Gestures

 Below are ten gestures derived from the transformation of movement in the solo works for cello and their respective compartmental taxonomy[34]:

1. Holding Extension—maintaining lightness   Trajectory: 2,4,8,10

2. Float—rotate—lift/Trajectory   Repetition: 3,5,9,10

3. Figure 8 stroke   In Extension: 1,6

4. Doppler Effect

5. Figure 8 roll

6. Extension—rotation

7. Suspension—rotation from core

8. Impulse

9. Embrace

10. Cross-Slap/Yi-Feng

These reasoning and explanations for each gesture are explain in complete detail in the next section starting with 3.4a. Once the development of the choreography began,

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[34] Gestures 9 and 10, were not used in the final research development and are omitted intentionally due to lack of strong findings in affordances, repetition of similar gesture seen in another work, or difficulty in transforming to the prosthetic instrument.

which is explained in detail in Chapter 5, a series of three section were created that housed different groupings of the ten gestures. The three sections, as mentioned above are: Trajectory, Repetition and In Extension.

3.4a Trajectory (2,4,8,*10)

The first set of gestures are extracted from composer's Claudio Gabriele's PNOM for solo cello (2005) and Edward Hamel's composition *Grey Neon Life* for speaking cellist (2012).These groupings were created based on visible muscular and expressive movement needed to perform these gestures and not necessarily corresponding effort actions. Unlike other groupings, these gestures' trajectory is built on direct or retrograded material.

2. float—rotate—lift (see Figure 6), is based on an intense recurring gesture that is sampled throughout the entire work, with the earliest appearance occurring in the first movement. Earlier utterances of the idea occur within a larger musical phrase and are treated more as a suspension in time that links to another idea. The example below is the extracted study from the fourth movement of PNOM, which from a descriptive point of view the performer is asked to accent an F natural and quickly crescendo to a fortissimo dynamic while varying the vibrato from slow and wide to rapid and tight. What is not included here is the clarity of intention. This gesture is a combination of Slashing, Gliding, and Pressing. The sforzando at the beginning—first half of the gesture — is initiated by the grouping of my right back muscles which gives the embodied sonic feeling of still floating through air. The second part is a contraction in the forearm and first finger which is done by slightly stiffening and adding a downward pressure to the top of the cello bow which gives the player the sense of pushing and pulling.

For the left hand, I continue utilising some of the same EBE's to create the sonic

and physical tension, but focusing on the primarily dominant role of the ancillary movement. When the vibrato starts, it is the elbow (ancillary) which allows for an ease of tension in momentum to guide the cellist to the halt. The elbow is thought of as a single limb that adds to the larger action, where its action could be manipulated by a sort of puppeteer. Looking at the expressive instructions that Gabriele has indicated with disregard to the pitch, above and below the notated pitch material, there is a clear prescriptive instruction, albeit lacking physical clarity in its performativity. The Float effort would be connected to the initial sforzando attack, followed by the vibrato (rotation) which is the muscular tension, and the halt, which is the lift. On a smaller scale, this gestural idea causes a repetitive disjunct in flow and phrasing, which is then quoted once more by retrograded material in the form of a tone row that was outlined in the opening of the work. The float-rotate-lift, conceptually for me, points clearly to a direct goal which continues to fall short in the form of forward-moving inertia followed by an interruption.
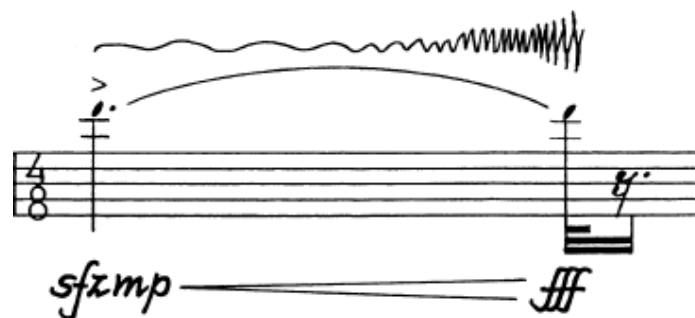
Figure 5: Excerpt of *PNOM* by Claudio Gabriele-float—rotate—lift

4. **Doppler Effect**—*Grey Neon Life* by Hamel was commissioned specifically for my investigation of physicality in contemporary works and is set to tag lines that artist Jean-Michel Basquiat (SAMO) wrote on his art works. This gesture was labelled as Doppler

Effect because of the increase and decrease in sound and physical activity over a short period of time within the texture. What is interesting and also problematic with this work is that it changes from performance to performance. Hamel intentionally left out pitch material in about 90 percent of the work so that it had an improvisatory framework, leaving the cellist with just the gestural movement to manipulate. Similarly, the sounds come directly from the movement in the same way as Lachenmann's *Pression* (1970)—the energetic effort produces the sound.

The descriptive material in Hamel's score differs slightly from Gabriele's. Figure 8 (physical sketch, see Figure 6) focuses primarily on the first two beats of the gesture. In the performance notes for GNL, Hamel states that 'Movement in pitch and physical space should be conjunct and in close proximity,'[35] which therefore limits the amount of expansion in space and time. This can be referred to as *gathering*. The spatial geography of the first two beats is calculated based on a study of proportions from one note-head to another, although sometimes there is a gap which is translated as large leaps or suspended silence through the physical movement. The trace-form line of the score mimics the shoulders of the cellist exactly, while the left and right hands work succinctly in receding from the focal point of 'action' while I am [the cellist] left with a feeling of sustained floating.

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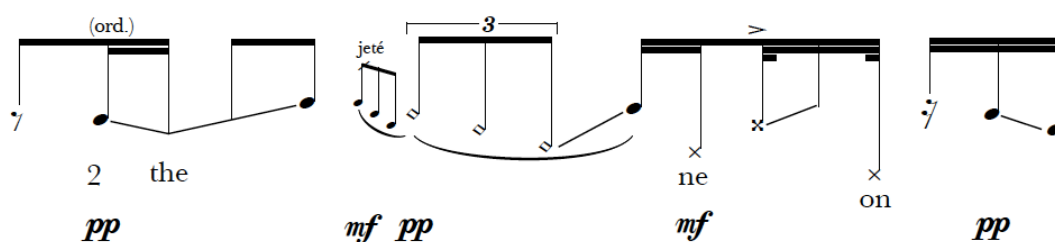
[35] Taken from the introductory performance notes of Grey Neon Life (2012) for solo cello.
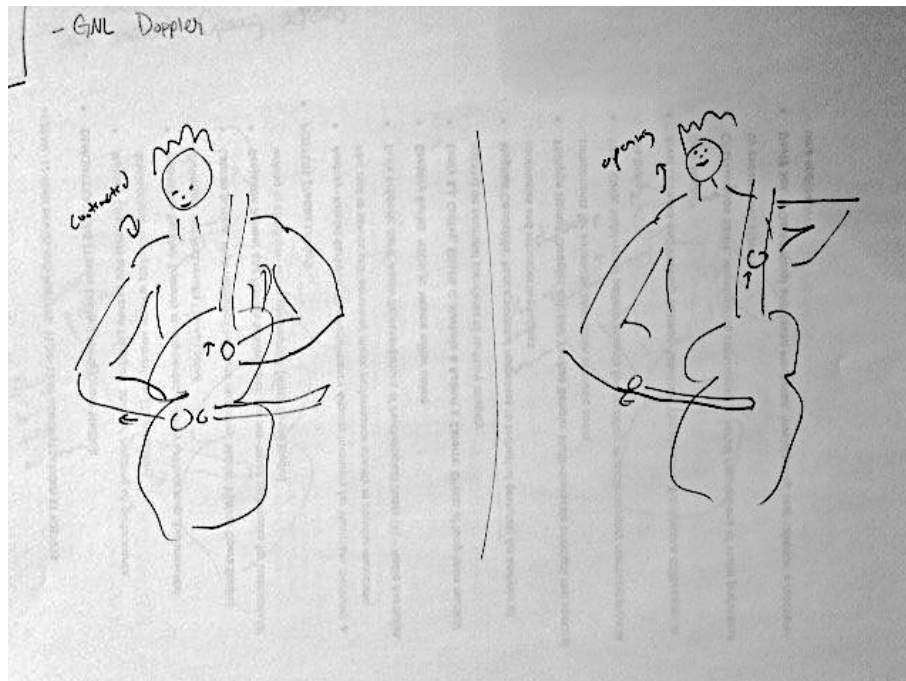
Figure 6: Excerpt of *Grey Neon Life* by Edward Hamel-Doppler Effect and physical sketch of movement sequence

The voice, in my interpretation of the work, mimics the bow exactly — by appearing and then melting back into the texture performed in the left and right hand. At the end of the full phrase we notice a reference to the beginning of the gesture, only this time both pitches are to be clearly marked (Slashing). Although the dynamic is marked "pp", the amount of energy and *tonus* (muscular contraction) used is substantial enough to notice a difference in my performance and a lackadaisical one. This expressive gesture is more about hearing the embodied flow than performing it, wherein the validation of the performance is guided by a low-level mapping of physical and tactile performativity that is subjective based on the player.

8.Impulse, extracted from Grey Neon Life, has a clear trajectory towards an explosion (See figure 7 and 8 below). The trace-form movement of my performance is similar to that of composer Simon Steen Andersen's Study for String Instrument #1 (2007), by way

of synced mimetic mapping in the left and right arms and hands. Although Hamel didn't give instructions to sync the left and right hands, I chose to create this type of choreography based on a physical fluidity that came out of searching for initial pitch material that sounded good and supported what I believe the choreographic text requested (see GreyNeonLife 1:07-:10 for exampled of synced hand and upper body movements). In the first beat, two dictated sounds in rapid succession are followed by a downward suspension in the left hand and an upward bowing in the right, resulting in the choreographic effort of *pressing*. By doing this I create the embodied feeling of sweeping air with a resistant force in space, or trying to push beyond a wall.
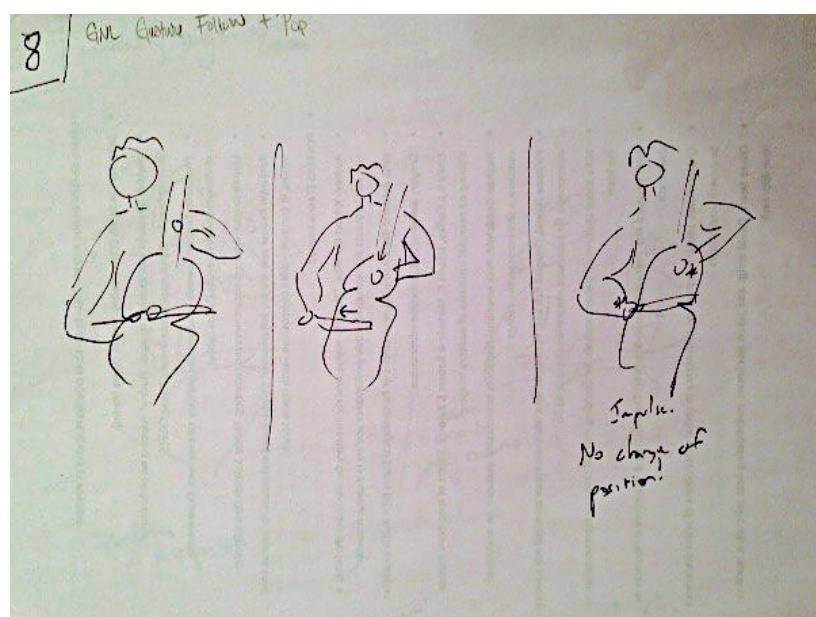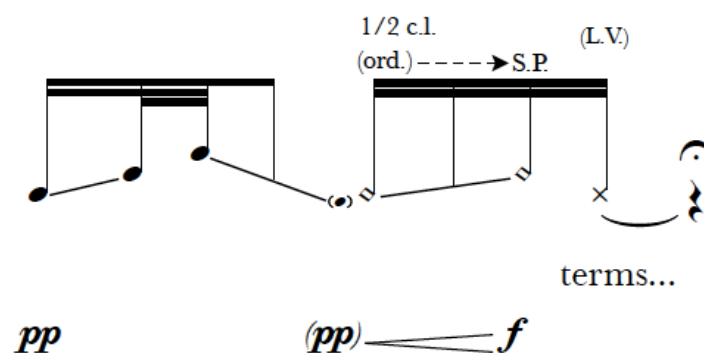
Figure 7: Excerpt of *Grey Neon Life* by Edward Hamel-Impulse Gesture
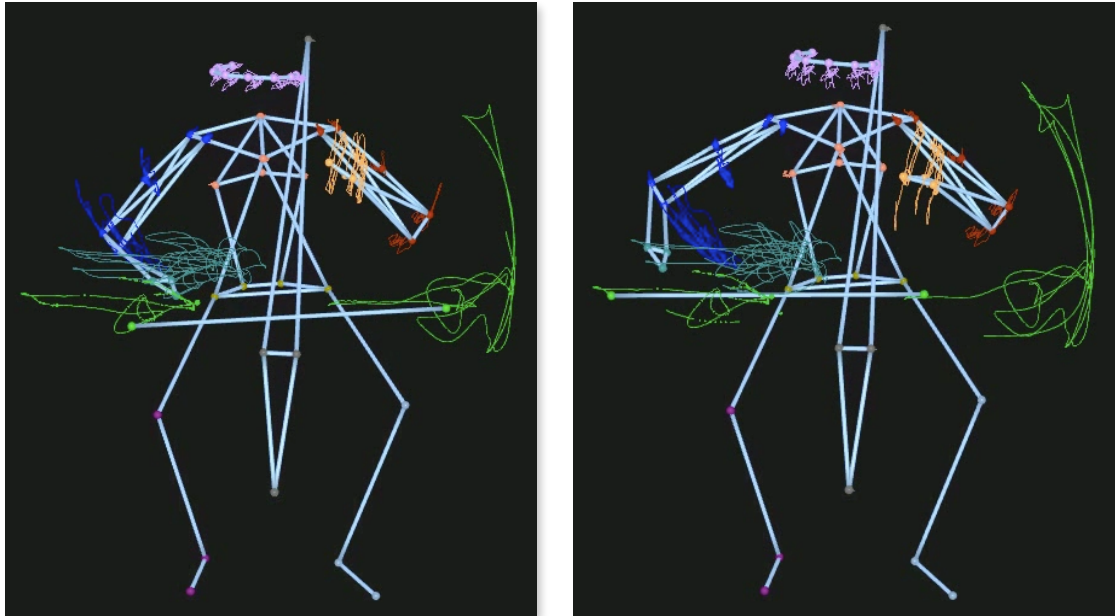
Figure 8: Isolated Past-Trajectory Motion Capture of Impulse gesture. Focus on movement amplitude of head and sync of given/received cues between left and right hand. Stills taken from the MoCap video BachPastTraj.mp4.

The second beat of the movement has a sonic result of glissandi harmonics that increases both in volume as well as timbral focus with an explosive pizzicato at the end. If we think of it is as a duet, the left hand guides or pushes against the resistance once more as it had done at the beginning, with a final Punching effort action at the end (the pizzicato). Within this conceptual approach, the arms alone shift back and forth between floating and contracting for a fluid continuity. Perhaps, one expressive notational tool that could help aid in furthering the descriptive notation and performativity would be the inclusion of a pressure symbol that dictates a trajectory of energies from low to high (just as there is in Labanotation).

3.4b Repetition (3,5,*9,*10)

This case study looks at the physical movement from Johann Sebastian Bach's *Sarabande* in the G-major Cello Suite. This study was only one in the series of studies

where I enlisted the assistance of cellist Elinor Frey as a subject to compare choreographic and interpretive styles. Due to the exclusivity of performance on some of the other works and time constraints, the Bach was the best study to use for quickly capturing and studying the performance process of another cellist. Elinor is also a special study candidate because she plays both modern and baroque cello, and it was beneficial to observe how her demeanour, style, and physicality altered from one instrument to the other due to different performative practices in both sitting position, bow hold, connection to the cello, and spatial freedom.

This multi-modal experiment-based research draws from both qualitative and quantitative approaches in expressiveness (Davidson, 1993), tension and phrasing (indicators of emotion and structural segmentation, Vines, Krumhansl, Wanderley, and Levitin, 2006), and performer and observer's perception of auditory information, affecting judgments of note duration (Schutz and Lipscomb, 2007) using Qualysis Motion Capture, live video performances and supplemented with the musical score. The Laban effort-shape analysis was also used for heightening understanding of expressive-action behaviour and muscular contractions that aren't as traceable by the naked eye or with MoCap, due to the instrument-specific motor expertise, subjective embodiment of the performer and that the cello blocks certain supportive muscular tensions (*tonus)* that occur in the core or hips of the body.

In the MoCap sessions, I was assisted by researcher Carolina Madeiros-Brum, and it was her recommendation that we capture not only "full performances," but also rehearsal and constrained performance attempts—which yielded astonishing results that included large amounts of extraneous movement amplitude in the head and knee when it was not expected or mimetic patterns on my back that mirrored the gesture from the score. It also brought awareness of extraneous and useful expressive movements, or mimetic traits that both Elinor and I as performers weren't aware of.

3. Figure 8 stroke

The Figure 8 stroke focuses specifically on the second measure of the G-major *Sarabande* (See Figure 9). The chordal structure[36] of the first two measures (which is more of a figured bass approach) is I-IV-V, and the 16ths that occur on the first beat of the second measure serve as a melodic passing phrase back to I (G major). In traditional performance practices of Baroque music (which the Cello Suites belong to), performers would categorise this technique as *durchführung*— which is used to describe the technique of melodic elaboration—and is often translated as 'spinning out'. The single voice polyphony should be treated as a variation of choral-style figured bass.

> He [Bach] recognised them more as figured bass structures... All the vertical dissonances in Bach music are related to the bass note (not necessarily the root) and receive proper contrapuntal treatment in relation to the bass note. The vertical structures were by-products of the combination of multiple melodic lines. Composers were definitely taught that certain vertical structures were used best in particular circumstances [i.e. that the dominant is a good point of arrival]. Bach was aware of vertical structures (in a figured bass way), and in what context certain ones appeared, but, for him, melodic and contrapuntal considerations were more important and shaped his music to a greater degree (Janof, 1995).

Figure 9: Excerpt of *Sarabande* from G major suite from the Anna Magdalena facsimile.

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[36] Bach chordal structures are commonly referred to as single voice polyphony. There is always a consistent number of voices implied in the melody—often four or five. Occasionally "strange chords" do appear, but I think this is due to Bach creating choral style figured bass that supports the polyphonic line.

This study, as well as the Figure 8 roll, are identifiable formulaic gestures (as explained earlier in chapter 1) which are treated as preconditioned patterns that recur over the course of the piece. The focus of this study was initially charged by a strong physical effort in the bow arm, which I identified as a Figure 8 motion that seemed to occur through a combination of instrumental and ancillary actions in the wrist and elbow.

Three separate MoCap sessions were taken of the *Sarabande*— normal (as if just practising), expressive (as if performing it on stage) and constrained (no expressive emoting in the body and lacking musicality). Each session delivered very interesting results, which can be found in the MoCap Sessions videos, that altered the states of effort and spatial amplitude as related to the right arm (See Figure 10 for the anatomical arm segmentation used in the mapping). Qualitatively, the plotted sessions (See Figure 11) showed significant differences in both the cumulative distance travelled based on the Right elbow (it serves as the anchor point for the range of motion), as well as position and acceleration. Upon closer look, an acceleration in position magnitude from constrained performance was detected. This was primarily due to the gathering in movement which restricts the range of motion. Although, the restriction allowed for a more swift and direct approach in performing the work.
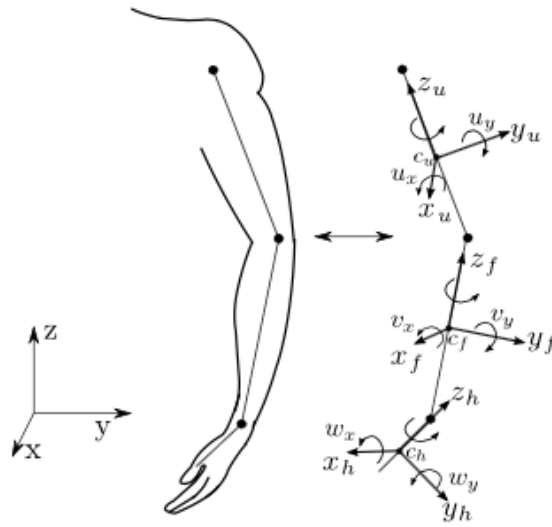
Fig 10: Anatomical arm segments showing the global and anatomical reference systems.
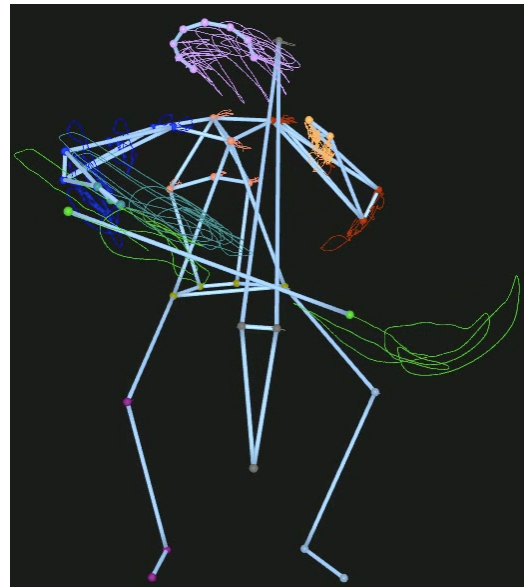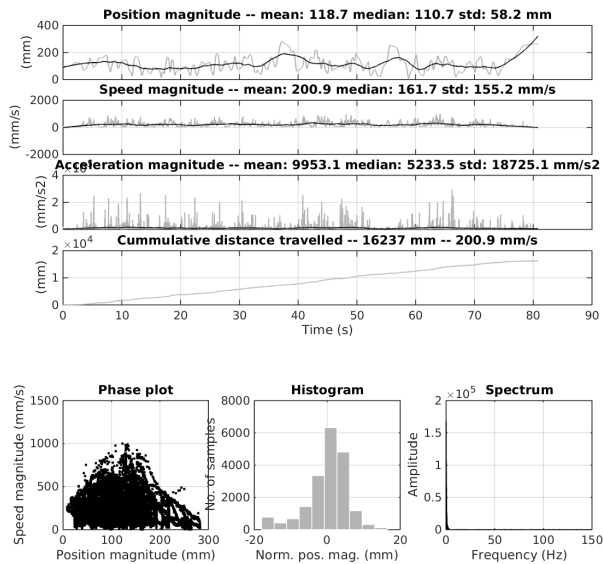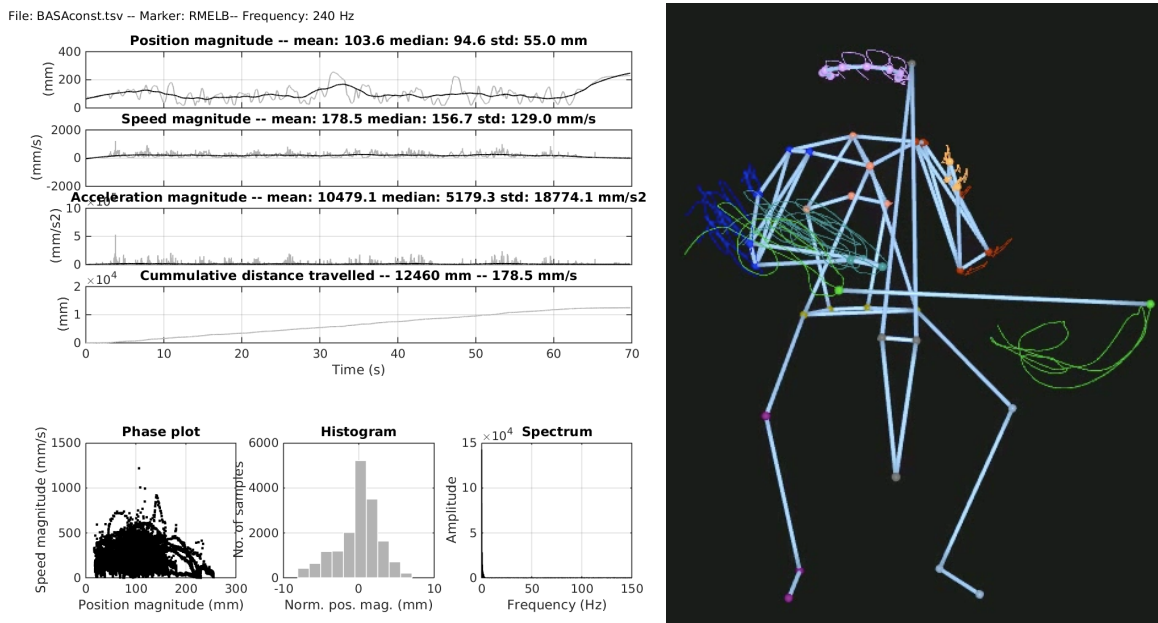
Figure 11: Qualitative plots and 3D visualisations showing Expressive vs. Constrained sessions over time and space of Seth Woods. The plots are located in the file "Bach and Hamel plots" and the screen shots of the MoCap session are located in "MoCap Sessions" under BachPastTraj.mp4 and Bachconstr.mp4.

Qualitatively, the overall sessions of my performances show a clearer connection to an ancillary gesture, my head. Between the three takes, the amplitude of the head was continually expressive and moved completely in-sync with the elbow, as if outlining the 16th note passage work and at times anticipated the expressive gesture.[37] This same action is seen in the D-major section of the movement. Further exploration of the movement for this gesture yielded embodied muscular contractions in my upper-body core. The *constrained* performance was a more plausible option visually for observing such an effort, due to the slower and more concentrated movements.

Next, I recorded performance sessions of cellist Elinor Frey with both modern and baroque cellos and bows. Given that the musical excerpt comes from the Baroque period, it was advantageous to see if changes in seating and connection to the instrument affected the treatment of the musical material and selected gesture. The

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[37] Both takes used the sound enabled video and silent observations which created sonic miming to lessen the influence of the sound enabled studying, I was able to view the ancillary gesture by adding past and future trajectory trace-form lines to the MoCap video. The future trajectory, when slowed down, showed an anticipatory amplitude from the head movement that was ahead of the actual gesture by at least 1-2 seconds.

first thing noticed whilst studying Elinor in live and recorded performances of the sessions was the ancillary amplitude was not in fact coming from the head as it had in mine, but the expression came from her hips (more focus in the right hip through higher elevation) and feet through given and received cues (in the form of a mimetic trade off between the two feet). Throughout most of her baroque performances, she stays rather still or concentrated without many extraneous movements that aren't related to goal-oriented actions.

The bowing between the two instrumental practices (modern and baroque) is of course different, as well as a one of the cellos being played without an endpin to anchor it into the ground for stability. Even with this understanding, her treatments of the 16th's show *gathering* and a repetition of rounding her shoulders inwards on both instruments in the excerpt as well as similar utterances of that pattern. When I alerted her to this observation, she had no idea that her shoulders moved in such a way. It's my belief that certain musicians learn certain physical mannerisms or motor functions that later become second-nature actions, which is all the more reason for conducting the research to uncover and heighten movements that in some way function independently.

The trace-form line of the musical material, which promotes a broadening in the shoulders, suggests an opening sensation that leads back to the tonic key, but her movement counteracts that normative approach through a clear, controlled, and embodied practice.[38] This observation is not to say her interpretation or playing style isn't valid, but it shows variances in physical movements from two different performers that still achieve musical results that are supported by subjective physical playing styles.

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[38] Elinor uses two down exacting down bow strokes that visually doesn't give the same visual or sonic effect as mine, but the musical idea is similar. Her movements therefore suggest a different trace-form line to that of mine and what I believe to be the musical idea for the opening chords.

5. Figure 8 Roll

This gesture (in the first measure of the movement, see Figure 9) was chosen purely from an embodied sensation of thrusting forward ("final destination unknown"). In my many years of studying and performing the suites, I have always been intrigued by other cellist's (sometimes violist's) approach to the first two chords. The weight and effort have always translated to me as being a sequence of low and heavy to high and light, but it wasn't till I studied the 3D MoCap videos that I realised I was creating the image of a figure 8 in both the elbow and the heel of the bow. This was done again through setting up both past and future trace-form line trajectories in the MoCap mapping to see patterns and residual movements that aren't possible when watching a performance in real-time. One could think of it as a short cut to capturing choreographic movement to either analyse or archive.

Figure 9: Excerpt of *Sarabande* from G major suite from the Anna Magdalena facsimile.

In my session there were two isolated movements that worked in tandem, but with two different visual and physical results. I begin the initial chord on an up bow and progress to a down bow that sustains the C before resolving. Harmonically, the musical emphasis is on the second chord which gives the sense of expansion, but in segmenting the two chords, I noticed that my torso and chest shifted away from the cello (to make a figure 8), while the right arm contracts inwards. The elbow initially begins down and

behind the torso, and ends up in front of the torso (again we have a gathering action) with a suspension (see MoCap session video BachPastTraj 00:00-:08). The IV chord (C-E-G in second inversion with a pedalled G hanging over from the I chord) creates a further suspension that keeps the shoulder up due to the sustaining C in the top voice. The over-arching sequence is an exact reversal of itself except that the right arm, which is led by the elbow (almost puppeteer in mechanics) with the wrist following last to sound the C contracts in the form to encourage the suspension of the leading voice. The final conceptual image gives the visual of a figure-8 (as seen in Fig 8).

To contrast this, Elinor's interpretation puts both chords on down bows which changes the initial image schemata of the figure 8 (see MoCap session Bachexp.mp4). Elinor's bowing choice instead creates circles which still reflect the energy of the gesture, only this time, the ancillary gesture is found in her wrist. The same utterance is executed in the B section that starts in D-major (the dominant of the G) which she again plays with two down bows (see MoCap session Bachexp.mp4 00:35-:37). The energy and time emphasise the 2nd beat, whereas my interpretation gives importance to the first and flows through to the second chord (seen in the expansion of 3D visuals). Elinor's movement starts with a sharp first chord and an expansive second. Put simply, little room is created for indulgence as I believe she is phrasing in 4 bar phrases instead of two (my interpretation), so she spares movement and energy so that she can reach the true peak of each larger phrase.

3.4c In Extension (1,6)

The final two case studies are once again extracted from Edward Hamel and Claudio Gabriele's solo works that were previously discussed. These case studies excerpts deal with musical material that creates both extensions and hyper-extensions in the body through an outward growth on the left and right sides of the body. Though both excerpts

are fleeting physical and gestural states, the Hamel excerpt is conceptually treated as a frozen frame in time where the left and right harms extend to their limits that meld back into the rapid and percussive material.[39] The Gabriele, unlike the other works previously discussed, uses a tremolo technique to outline the programmatic quote of a "cry" (translated from the Italian word Grido) as annotated at the beginning of the score. Th Gabriele excerpt is a very fragile section that balances between being thin, light, and heavy.

1. Holding Extension

The Holding Extension gesture is in the form of a harmonic trill (See Figure 12 on next page) that occurs midway through the first cell of un-pitched gestural material. Hamel explains in the performance notes, 'Harmonic touch. *Does not* have to be a conventional/functional harmonic. More focus on the touch than the resulting pitch.' Given the physical nature of the work, the difficulty lies in devising a choreography that enables the cellist to perform the notation (sign) at an extremely low dynamic that is focused, indeterminate in pitch material and delivers an intense and fleeting sensation. In developing a meaningful translation of how this could be achieved, I looked back at the beginning of the gestural cell and noticed that the iterations of the indeterminate "harmonics" versus stopped pitches are rather sparse and based on a gliss-hit-gliss theme.

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[39] I visualise the action of an archer engaging a bow and arrow and releasing it. I relate that sequence to the Hamel sequence.
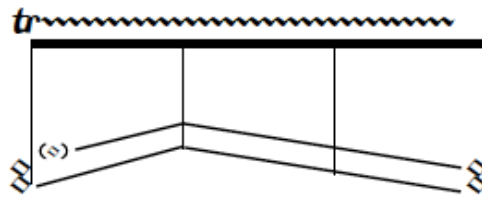
Figure 12: Harmonic trill excerpt from Edward Hamel's *Grey Neon Life*.

The object being analysed is a chord made up of two artificial harmonic root pitches and an upper-note that is trilled in-sync with a glissando. The initial shape or schematic image resembles that of a compass (with the cellist's left arm hyper-extended in the northeastern direction and the right arm/bow drawn out due west). A slow simulation of the trill/glissando action shows three highlighted features: the inward rolling of the right shoulder by way of a contraction (*gathering),* slow but fleeting bow movement east, and the left elbow and hand oscillating back and forth to create the trill/glissando effect (see GreyNeonLife 00:50-52 and MoCap session GNLpastraj 00:30-32). With the dynamic marked at "ppp" there is a carefully concentrated balancing act that needs to happen to successfully produce both the musical gesture and physical gesture. The root of both the trill and glissando are anchored down by my left hand thumb, but with a shift between light and heavy pressure in both the thumb and trilling finger (I chose my third finger as it was the strongest to produce the rapid percussive like touch needed). My final notes of this gesture stated that a pronation in the left finger (to allow for a focused and fleeting effect in sound production) as well as the embodied feeling of the upper body contracting in and out (resembling an embrace) allowed for my personal recognition of the successful execution of the expressive gesture.

6. Extension Rotation

The final excerpt of expressive gestures deals exclusively with the right hand in Gabriele's PNOM for solo cello and represents a balance between fragility and power in the composition and performativity (see Figure 13). As previously mentioned, this gesture is a reference to a "cry" effect by creating a stiff tremolo with a glissando (see external Youtube PNOM video 6:30-:43). In analysing the MoCap videos and recorded performances in Switzerland, I took interest in the trace-form shape of the right arm. I decided early on that this passage would need to be executed mostly at the tip of the bow (while pronating through the left finger for constant control of the sound) due to Gabriele having written the pitch material in 7th position on the fingerboard. While reviewing the recorded performance, I noticed a normal extension in the right hand that progressed to a hyper-extension, and finally a rotation in the wrist with heavy pronation to support the crescendo to fortissimo (ff), as well as the level of physical intensity.
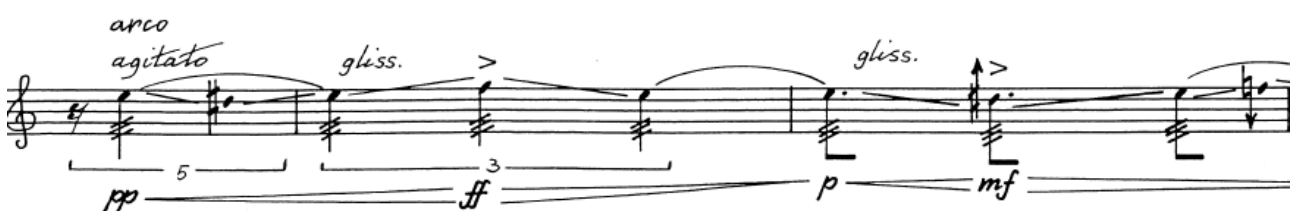
Figure 13: Tremolo + extension excerpt from Claudio Gabriele's *PNOM*.

To a certain extent, Gabriele provides a clear level of notational descriptors for the structural arch of the gesture. The only adjustment(s) I needed to make were the amount of force in the form of effort and distribution of bow to support the crescendo and decrescendo that occur in the excerpt (ff and mf). The one component that brings this gesture together on an embodied and sonic level is utilising the rotation of the wrist prior (the ancillary gesture) to the crescendo. In executing this gesture, it affords a stronger control over gripping the string with the bow hair and giving the same sonic

effect had I played the passage at the heel of the bow. The gesture's design and production are essentially a sonic and visual illusion that on one level allows the listener to imagine a weeping and jittered cry, and on the other, a physical choreography that requires immense amounts of effort and is translatable to the observer watching and listening. Therefore, what you hear does translate exactly to what you see.

3.5 SUMMARY

In reflecting on the case studies of Bach, Gabriele, Hamel and Lachenmann, I've observed varied degrees of information that proved useful in the studying of not only the moving musician, but also in the juxtaposition between the "moving score" and the human body. As is obvious, there were different methodological approaches used to gather information or support another system of data retrieval. This was due to my realisation that each composition required different physical processes in learning and performing the works. Connections were made between the jabbing techniques in the Lachenmann and the ancillary wrist gesture in the Gabriele. Although these are executed on opposite hands, I found mirroring physical identities that became clear patterns in the other works. Having gone through all the solo works and useable data, I saw where I could continue the research in studying physical and gestural behaviour of musicians, and eventually develop a new interactive work for cello and prosthetic Spine. By comparing found movements, such as the high movement amplitude in the head, knee, or "freeze-frame" image in Hamel's GNL, I realised these discoveries could be used in a machine learning process to teach the Spine those gestures and later control an electronic soundscape with it.

The case studies were not a mere study in finger and bow placement, but an in-depth approach in deciphering musical scores, both flexible and contained notational mediums, through my own physical language in working with the cello. The exciting

discoveries for me came from the scores of Hamel and Lachenmann. Although Lachenmann notated specific prescribed actions, the clarity with which this was done remained slightly hazy, but useful in re-analysing the relationship I have with my body and the cello. The same is true when I worked on the Hamel score for performance and in segmenting movements for the motion capture session. After receiving a score that consisted mostly of a context-sensitive language (Chomsky, 1963), it forced me to address my process of learning and playing, but more importantly, how to approach movement in a controlled/free environment where not all directions are loosely given. That is to say, these compositions suggest an end goal with more indirect freedom given to the interpreter, and through analysing the language and symbols, I learn more not only about the sonic world they try to achieve, but also about my own practice on a technical and artistic level.

In regard to the Qualysis Motion Capture system, it was the best tool I could have used to capture and segment multiple joints of the body all at once. As stated earlier, I colour coded each joint of the body and cello with 29 markers so that measuring and doing past and future trajectories would be easier in the cleaning and scrubbing of the data in the post-capture phase. Although the success rate of data captures is high, I chose to supplement the findings with Labanotation and recorded performances to reference movement in both my sessions and Elinor Frey's. To date, I cannot think of one motion capture system that is truly able to capture movement, gait, and expressive subtleties with at least a 95% success rate. Therefore, researchers such as myself, Bertha Bermùdez and Emio Greco (Capturing Intention), and William Forsythe (Synchronous Objects) have tried to devise new ways to both capture, measure, and archive movement to help better understand how we function, create, and ultimately use that knowledge and results to disseminate it to the next generation of performers and researchers interested in studying and archiving expressive movement and gestures.

CHAPTER FOUR
Noise Inside/Out-Choreographic Experimentation

In chapter 1, notions of gesture and practical application were discussed, as well as how it forms the backdrop to deciphering my work on movement as a musician. The exploration into gesture is guided by scholarly and practical research done by choreographer William Forsythe and musicologists Anthony Gritten and gesture researcher, Marcelo Wanderley. Chapter 2 serves as an overview of Rudolf Laban and his theories of Choreutics and Eukinetics. These theories form the basis behind the analysis on the kinetic movement seen in the solo cello case studies. Chapter 3 implemented that work as well as brought in supplementary sources of Motion Capture to help further understand what it is we are looking at and how to move forward in further identifying instrumental gesture patterns and ultimately engaging in embodied interaction with score and subjective self. This current chapter draws on all the material discussed previously and shows the practical use of the body with and without my cello as an expressive tool to communicate.

Historically the body and the mind have always been positioned either together or against each other.[40] My focus for this chapter is to draw connections between the self (body) and the choreographic object. The first part deals exclusively with the *inter-subjective body*, and how through exploration of listening to what the body wants and is capable of, gives way to levels of sonic embodied sensation, reflection and understanding in my practice as a musician and mover. The second part focuses on the choreographic object. The choreographic object is a reflection on the design and craft of the idea, and is referenced and aligned with thoughts of Forsythe, Mark Johnson, Immanuel Kant, as well as choreographer Meg Stuart's creative processes. This chapter

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[40] Plenty of examples exist in linguistics, theology, psycho-analytics, and Objectivism.

addresses how choreography as a tool can be self-encompassing and independent of the body. It is very common to associate choreography and dance together, but I believe— just as Forsythe, Johnson and Kant—that the singular idea of the *choreographic object* lives on its own and is separate from the moving body.

The *inter-subjective body* is an area of research informed by Deleuze and Corporeal Feminism and advocates for the connection between somatic-informed movement practices that bring a connection of the mind and body into one stream of functionality. Dance theorist and lecturer Natalie Garrett Brown argues that the intersubjective body '... is a lens which revisions humanist and understanding of self as stable and given, thereby aligning with contemporary philosophical concerns that presupposed an interconnection of mind and body' (Brown, 2013, p.24). Specifically, the intersubjective body is a lens that looks at the exploration of bodies in connection to the environment and is an exploration of corporeal exchange between dancers or movers.

The case studies offered in this chapter are drawn from my experiences and work as a mover and cellist in the last 3 years. These studies draw on my advocacy for understanding how the body truly functions with an expressive instrument and also away from it. As a contemporary mover, these years of research have been one of engaging with myself on a subjective level and developing a new way to connect to movement as a musician that hadn't been done before. I took part in numerous workshops on Contact Improvisation, Body-Mind Centering, and remounted experimental and fluxus works, all with the goal of trying to identify and reflect on my association to movement and link it to sonic embodied states.[41]

This chapter, therefore, offers a play between hypothetical and real case study. The perspectives presented are characterised by a range of subject positions from which they are written. At times I am the observer, and at others the observed. Within this

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[41] More substantial information may be found on Body-Mind Centring in the following book: Cohen, J. and Weiss,G. (2003) *Thinking the Limits of the Body*, New York: State University Press

approach, the case study examples offer accumulating experiences that myself and others use to manifest an understanding of the body in contact with other dancers and/or musicians. An overlapping of case study, theoretical, and practical processes is presented and unveiled as a probable lived experience, for the outside reader, as a way to better understand movement subjectively. To frame this section within an obvious contemporary practice, I present three key characteristics explored:

- touch as a mode of communication
- somatic mode of attention (trust)
- movement as a chorus

These three characteristics as framed within *inter-subjectivity*, presuppose that the body is a closed and predetermined entity, but for the sake of my research, I suggest viewing the body as an entity that is open and permeable to all things around it.

4.1 QUARTET AND FOUCAULT'S *HETEROTOPIA (*OF OTHER SPACES*)*

In the summer of 2013, I embarked on a 1.5 month research residency in La Rochelle, France to investigate physicality in the solo cello works discussed in the previous chapter. During the residency I began a collaboration with the local dance company SINE QUA NON. Through experimentation and trial-by-fire we slowly crafted a work that would later be toured. The emphasis of this section is not on the finished work but the experimentation phase. We began with a series of weight transfer and trust exercises. For the first time in a long time, I had finally come back to the dance world not as a cellist collaborating, but as one of the movers and I must say that I struggled in the beginning. I was trying to support and control both their movements and mine. It felt

like I was trying to carry the world and the inhabited craft all by myself. Eventually I got it. I had to listen, feel and say something by being in my body and theirs at the same time. This was the first step on the way to truly unlocking something powerful and fulfilling. From a reflective perspective, I find that when performing with the cello, I am personally aware and in control of the instrument. There are things to fight back against, but technically there isn't any weight to share, but to distribute instead. I still use these exercises now amongst my music colleagues as a way of connecting away from our instruments in the form of shared corporeal chamber music.

As we began working on the creation of a piece, choreographer, Christophe Beranger, mentioned the idea of exploring the world of Foucault's Heterotopia (sometimes also referenced as *Of Other Spaces)* as an inspiration. To 'unbox' this, Utopia is the inversion of the current place or space people inhabit, so Heterotopia is its inversion. It is not an inversion of our current place, but of all places other than the nowhere. Heterotopia's have been identified as both crises and deviations, they change in function and meaning over time (as it is connected to "synchrony"), and function like a system of both opening and closing. In effect, it is both a place that is isolated and penetrable. Much like the focus on the penetrable body and space around it, *Heterotopia* serves as a perfect state of imagery to explore the sensation of touch and communication, while steering both my body and the observer/listener in the same space or transport us to a different one.

Earlier, I spoke of the permeability of the body or soma (the self). As a quartet (myself and SINE QUA NON) we'd explored the feeling of trust and weight distribution from skin to skin and ligament to ligament. The newly presented challenge was how to develop a structure that we as a 'corps' could build on, infuse support, and permeate so that it was not completely closed off to the spaces and environments around us. Dance scholar, Anne Cooper Albright states that contemporary dance practices cultivate a

somatic mode of attention and can serve to shift a dancer's embodied knowledge of his/ her relationship with the world (Albright, 2001, p. 3).

> If the world is already inside one's body, then the separation between self and other is much less distinct. The skin is no longer the boundary between the world and myself, but rather the sensing organ that brings the world into my awareness. In this intersubjective space in which one can be penetrated by sensation both external and internal, the heretofore unquestioned separation of individual and the world (or me and you) becomes more fluid. What I am talking about here is the possibility of re-conceptualising the physical borders of bodies through attention to sensation (Albright and Gere, 2003, p. 262).

The quartet devised structures that were secured and guided mostly by the arms (think of it as chained links). We worked to secure links even with changes in movement, pulse, quick energy shifts and levelled dynamics. This process started to resemble more of the reflective analysis seen in Eukinetics. There was a particular moment in the piece where myself and dancer, I-fang Lin, have a duet that is filled with sporadic and explosive moments of pulling, twisting and thrusting (see The Quartet video 2:33-41). This quick sequence visually resembles the cracking of the quartet walled infrastructure, redefining it, as well as altering the gaze and dimensionality of the edifice. The repetition of dominant/submissive energies played heavily in the function of the duet. Initially, I constantly fought against myself and I-fang, but only as a way to understand the positioning of her energy, weight, as well as where she would take the group next. Eventually I stopped trying to only 'feel' the movement, but also 'hear' it . 'Bodywork' Practitioner, Deane Juhan, surmises this revelation perfectly; 'By rubbing up against the world I define myself to myself' (1987, p. 34). My function was not only to work as a link to the edifice, but shift the meaning of the quartet. Can you be both a link and an instrument to dismantle and redefine its meaning and purpose? In deconstructing the senses and physical transitions of the body, the focus on the intersubjective body has become even more apparent and of true importance because of the subjectivity that 'is revealed as a process of becoming through the sensory-perceptual feedback loop that

relies on all the senses, not just the ocular' (Brown, p. 30).

When looking for different subjective processes, I found inspiration from the work of choreographer, Meg Stuart. In her book *Are We Here Yet?* **(2010)**, she guides the viewer through the archives of multiple works throughout her career. Of particular interest are the interviews and reflections of the dancers that have worked with her as both dancer and choreographer. In regard to communication and 'felt sense' dancer Philipp Gehmacher reflected on the feelings and fleeting states that are connected to them:

> You had to understand the physical structure of that state and try to separate it from the moment when you start to represent, when you give names to the material or the sensation…Feelings come and go, you cannot always name them; sometimes many feelings are present at the same time (Stuart, 2010, p. 22).

This sense of feeling or connecting is a fleeting sensation that never truly connects to you the same way each time; just in the same way I will never play a musical line the same way twice. As creators, we spend a large portion of time creating rules and structures for support that we eventually try to omit in performance. It is not so much a case of aphasia[42] with regard to parametric structuring, as it is an omission of barriers so that liberated feelings are possible in any given situation. Are we as performers aware of the states we develop, enable, and inhabit, or are we just going through the process? Merleau-Ponty states, 'I do not need to visualise external space and my own body in order to move one within the other. It is enough that they exist for me, and that they form a certain field of action spread around me. In the same way I do not need to visualise the word in order to know and pronounce it' (Merleau-Ponty and Smith, 1996, p. 210). He connects the 'representation of movement' to a verbal image, which can be seen as a structure or unspoken language which is innately already there — even though it's unspoken — and can be called upon when needed. Once a structure is built and the

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[42] Merleau-Ponty talks about aphasia and anorthic (loss of power of articulate speech) in the chapter The Body as Expression, and Speech from the book Phenomenology of Perception (1996).

performer has labelled it, he is able to express freely without restriction or questioning. The performer then only needs to focus on the style of communication in the space and disregard the structural boundaries. By focusing on sensation and communication as a way of shifting the space, it inverts the quartet and the subjective bodies it is composed of. In the next section I focus on the structure and choreography as a singular tool that is both independent and dependent of the soma [the body].

4.2 ARE WE HERE YET?

In 2014, I took part in the creation of two new works. One for solo cello and transducers and the other a large ensemble piece for both dancers and musicians. Each project brought about different challenges in the creative and research process that will be presented here. The aim is to look at the idea or object of choreography as both a tool and independent channel that guides action.

In the philosopher Mark Johnson's book, The Body in the Mind (1987), Johnson sets out to investigate and defend three controversial claims around imagination, or better yet, human imagination, and how its absence would give us no connection to meaning, make sense of our experiences, or reason towards knowledge of reality. In using his position and defence, I apply what he calls Objectivism (an ideal that all properties, ideas and objects are involved in the reasoning of how we understand and experience reality) to choreography as both object and expressive tool. This is not to confuse choreography with dancing, as it is independent of the body (dance) and can function as an expressive tool for design in reality. 'Reasoning to gain knowledge of our world is seen as requiring the joining of such concepts into propositions that describe aspects of reality. Reason is thus a purely formal capacity to connect up, and to draw inferences from, these literal concepts according to rules of logic' (Johnson, 1987, p. x).

4.2a Bodied Chambers

Bodied Chambers (2014) is a conceptual work developed by composer Patricia Alessandrini and myself for cello and transducers that investigates different aspects of interference, whether it be via physical movement, external objects, or the choreographic object itself (see Figure 15). Research began with a preliminary research/creation phase that stemmed from a contact improvisation session in La Rochelle, France, and a collaborative creation with composer Patricia Alessandrini exploring found *objects* and *corporeal* interference. The interests lie in the following strands: gaining a closer association to the embodiment of the language itself, the musical *identities* of movement presented in and out of the score; the performer [myself] and his [my] physicality; the composer's intentions and the text; the shift from the expressive instrument to the human body.
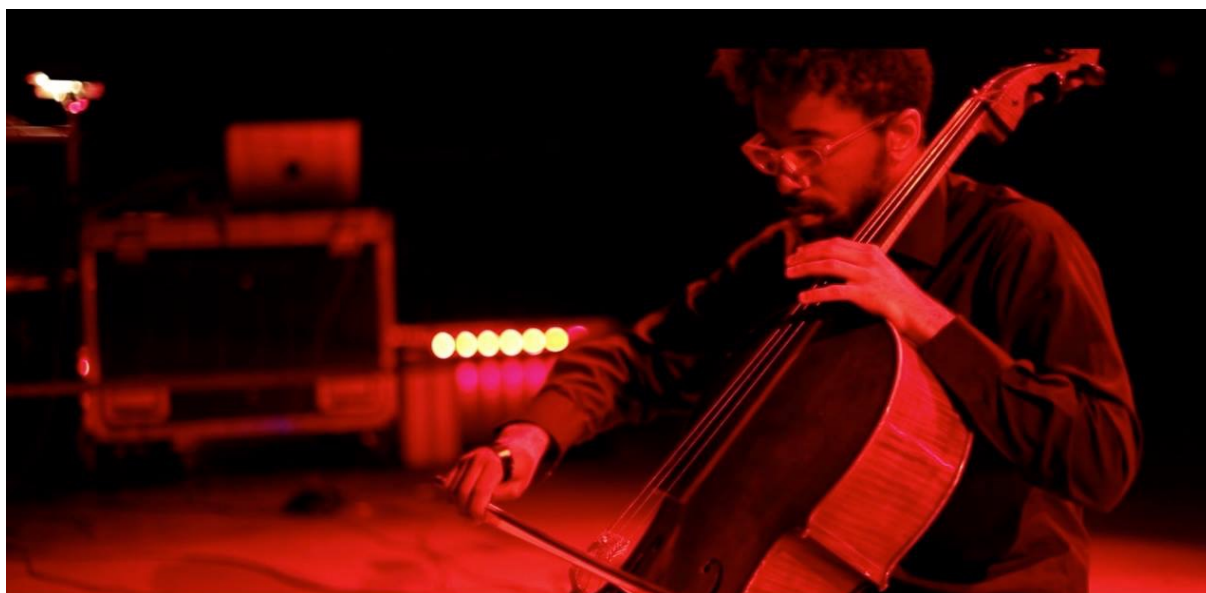
Figure 14: Bodied Chambers still photo from Festiwal Istalakcje 3, Warsaw 2014. The image shows the very beginning of the work which is performed kneeling on the ground without a chair.

The common problem found in the early stages of research was the lack of coherence across the disciplines in regard to terminology and the understanding of movement and gestures. Defining our positions as well as a unified terminology proved problematic. Facing this division brought about by orality and technical dissemination, we resorted to using the body as the entry point

Bodied Chambers is 'somewhat outside of the standard instrument and electronics model, as it does not involve sending electronic sound through speakers, but rather through the body of the cello itself' (Alessandrini, 2013). For this piece, I wear a set of transducer membranes, inserted through a button-down shirt,[43] which allows me to act as the environment that alters the aural and visual aesthetic (see Figure 15).

Wearing the technology:

contact microphone: either attached to clothing or lightly stuck or taped to the skin at the clavicle

two transducers: buttoned, sewn, or taped into clothing

miniature microphone: to be worn on the bow hand, taped on or just below the palm

all cables should be passed under the clothes, and gathered to the right side of the cellist, to avoid any interference when changing position

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[43] The insertion of the membranes into the shirt I wore in the early stages was DIY, but a later version using a haptic sensor design helped perfect the aesthetic as well as the performability.

Positions and transitions:
each of the three main positions
should be held for 3-5 minutes

1 | kneeling position

drop back the pelvis towards next position (bottom transducer no longer in contact with the cello)

lean slowly backwards

sit and bring the legs out from under the body, turning the cello around
(top transducer no longer in contact with the cello)

2 | sitting position, cello on lap
(bottom transducer only in contact with the cello; this position is ideal for playing behind the bridge)

lean slowly backwards, turning the cello around onto the body
(bringing both transducers into contact with the cello)

3 | lying-down position, cello lying on the body
(you may choose to just play with the two hands rather than bowing for this section)

nota bene: this piece is most comfortably performed using a soft surface, such as a carpet or yoga mat

Figure 15: Wiring and performance positions of *Bodied Chambers*

The technical design is a mixture of analog and digital technology, as both the analog feedback and digitally transformed sound (using Max/MSP programmed created by Alessandrini) are re-transmitted through the transducers and enable me to capture the sound of the cello, in part through the resonance of my own body, and re-transmit that sound through the instrument; thereby creating a feedback loop. 'Within the loop, the sound of the cello is processed in real-time, creating the illusion of altering the resonant properties of the instrument itself. The latter aspect is informed by current research by the Active Musical Instruments including Virtual Adjustments (IMAREV)[44] research project at IRCAM, led by Adrien Mamou-Mani' (Alessandrini, 2013). This experimental work is

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[44] The focus of IMAREV is on developing new models, algorithms and tools for physical modelling in conjunction with active instruments (a family of innovative musical instruments). IMAREV site: http://www.ircam.fr/instr.html?L=1&tx_ircam_pi1[showUid]=73&ext=1

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performed on the ground without a chair, so in essence we strip the traditional aesthetic of how the cello is performed and its sonic output. 'The movement was at times the driving impetus in the first experiments, making the sonic output somewhat secondary at times' (correspondence between Alessandrini and Woods, August 2015). We positioned it within the realm of *musique-concrète* and *musique-concrète instrumentale*, whereby we borrow from the "found" sounds of playing the cello as well as finding the inner workings of the physical or choreographic nature that give us a resultant sound. The bigger emphasis is on the 'What happened?'[45]

Continuing with the idea of 'What Happened,' the piece begins with me kneeling on the ground with the cello upright and improvising around a conceptual idea of "found industrial sounds" using a mesh aluminium preparation,[46] which encourages the overtones of the 2nd,4th, 9th, 10th and 11th partials. By altering the pressure applied to the preparation, different clusters of partials are ignited (see BCV.mov video 00:10-00:45). While continuing to improvise around this idea, I begin to slowly descend backwards till I arrive on my back (See Fig 16 and BCV.mov video). Over the course of the piece, Patricia fades and feeds the signals from the microphone in my right hand, which is also holding the bow, the contact mic placed at my throat, the two transducers that I am wearing, the processed cello sounds from the aluminium preparation, as well as pre-existing sound material used to shape the harmonic colour. These layers create an evolving feedback-loop wall that is initiated by the constructed improvised movements and the high pitch frequencies developed which I manoeuvre in-and-out of freely while still being aware of the restrictive structures built in and around me.

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[45] The 'What happened?' idea comes from an interview with Lachenmann from the Slought Foundation on his aim in creating works in this medium of contemporary musics.

[46] Reconstructed from the resonator that Giacinto Scelsi and Frances-Marie Uitti created for his string quartet and solo cello piece Triphon.

4.2b The Funerals

Figure 16: *The Funerals* with P. A. R. T. S. and Ictus Fellows (photograph by Bart Grietens)

The second project was a creation titled *The Funerals* between dancers from P. A. R. T. S., choreographer, Andros Zins-Brown, and musicians from the ICTUS Ensemble (see Figure 17). The aim of the project was to create an evening length work that brought together both dancers and musicians who would learn a musical score that didn't utilise any orchestral instruments or set choreography.In this way, all parties met on an equal collaborative field. Each performer designed a new instrument that was not reflective of our original instrument. In creating the work, we used an excerpt of Francesco Filidei's *I Funerali dell'Anarchico Serantini (2006),* which is performed only using the face and body. This was a work that the musicians had already learned and was in their repertoire, so we taught it to the dancers. Following the musical score session, we explored the physical aspects of the instruments that we had all created, including the investigation of the weight, interference and space around it.[47] These characteristic elements definitely aligned with Laban's Eukinetics from the LMA. A series of 4-5

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[47] The original instruments ranged from wind-chimes, hand percussion cymbals, thunder sheets, "Woodwind instruments," a clave, a hypothetical string instrument using a violin bow and concave metal top which creates sounds similar to the singing saw.

"gestures" were to be created individually, and would be used for the instrumental and ensemble sections of the work.

In the second half of the piece, we improvised a musical score with the created instruments and transitioned to the miming of those instruments, but not constantly (see The Funerals video 7:00-14:30). A suggestion was made to sing the previous composition that was created by us as a collective, and inserting more stillness than active playing. The miming movements shifted from clear to abstract and dissipating into one of three directions: a) Minimising (bringing the focus of the movement to even smaller segments, or the production of the instrument's sound becoming physicalised on a smaller scale, b) Think of the space around you as resonant, and allow your movements to produce sounds which you control with the texture of your movement, c) Imagine the sound your instrument would produce in the space and think about that sound feeding back into your body — so you are not "dancing on the music" but increasingly embodying the quality of the sound your instrument would be producing. I chose the latter as the final arrival point since we were grouped into smaller and larger groups that would eventually create a pseudo-chamber ensemble aesthetic, and allow a rippling affect in the coordination of movements. Each sectioned group had a main energy focus that guided and transformed the aesthetic, timbre and pulse of the group. The foci of each group (functioning independently) would eventually speed up the pulse, and would in effect cause the members to exhaust their sound-movement till they eventually die (see The Funerals video 11:00-14:00).

4.3 Reflection

Objective View (arc)

The Objectivist take on life and experiences is close to what Johnson calls the "God's-Eye-View" about how the world really is; we're looking at the objective world as it is

without definitive judgement. In this world there is an ultimate being, and within it we find a link to understand it. The same can be connected to the two works mentioned above as they both took conventional methods of expression (Music and Dance) and found or made room for interpretation of them. The mode of expression for music didn't need to be with orchestral instruments, sitting in a chair or steeped in the Western ballet tradition. With this mindset, I, just as Johnson, believe there is room for interpretation while still using the classical Objectivist model. 'The classical view holds that categories are defined by necessary and sufficient conditions which specify the properties shared by all and only members of the category. Recent studies show that, although a few of our categories fit the classical model, most of them differ insofar as they involve imaginative structures of understanding such as schemata, metaphor, metonymy, and mental imagery' (Johnson, pg. XI). One such deviation of structure is choreography due to its manifold designs in structure, translation, intention, and execution.

Choreography in the purest form is an object 'that presides over a class of ideas: an idea is perhaps in this case a thought or suggestion to a course of action' (Forsythe, 2009). Forsythe argues that 'Choreography elicits action upon action: an environment of grammatical rule governed by exception, the contradiction of absolute proof visibly in agreement with the demonstration of its own failure. Choreography's manifold incarnations are a perfect ecology of idea-logics; they do not insist on a single path to form-of-thought and persist in the hope of being without enduring.' If choreography is a basis of idea-logics that is eventually broken down by subjective elements, then it should be viewed as the meta-schemata within Objectivism. The *schematic* structure is the base design that choreographers and performers use to elaborate upon. The schemata of these structures aren't rich, expansive or concrete images, but ones that organise the mental processes from something general and abstract into a particular

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form. Immanuel Kant argues that the schematic structure is not the same as or can't be identical to the image (schema). The image doesn't share the same features but builds on or contains structural features common to many different object, events, activities and bodily movements.

> 'No image could ever be adequate to the concept of a triangle in general. It would never attain that universality of the concept which renders it valid of all triangles, whether right-angled, obtuse-angled, or acute-angled; it would always be limited to a part only of this sphere. The schema of the triangle can exist nowhere but in thought' (Kant, 1965).

In referencing 'thought' Kant suggests that the schemata are more than physical processes and have a reality as structure that are based on mental representations. In reading this I am reminded of Forsythe writing about Jacques Lusseyran, the blind French resistance fighter, who wrote about an inner sense of vision that enabled him to see and manipulate forms and thoughts, almost as if working on a boundless canvas, as well as the blind mathematician Bernard Morin who describes the process of everting a sphere, which is similar to my approach of dissecting the choreographic object or musical score and seeing it from different angles than the one originally presented to me (Forsythe, 2009).

In *Bodied Chambers*, there are multiple expressive and finite elements which make the difference, but in the creative process, Alessandrini and I kept returning to the idea of the schematic structure. Envisioned and built on an idea of three transitions, I devised movements that would connect the structural states together through repetition of analysing and systematically organising the main corporal and touch-based (using the hands only) states. From there, the process of assigning expressive elements took place. In *Funerals*, the same process was used on both a micro- and macro-level, fluctuating between my personal movement, the smaller ensemble that I was grouped within, and the entire dance corps as a large body.

Subjective (singular)

Rich images enrich the expressive elements within the structure and assists the performer in understanding the structure of the idea. When the function of those elements and its relation to the me are clear, I am able to re-write and re-engage with the structure. Earlier I spoke of a structure that was both closed and permeable, and the same idea applies here. Choreography and dance are two distinct and different practices, just as composer and performer. Forsythe suggests that when 'choreography and dance coincide, choreography often serves as a channel for the desire to dance,' but then this could easily infer that choreographic thought or structural building resides exclusively in the body. The structure and the expressivity are separate entities that have independent roles, but can/do function together. Johnson explains this as containment, or *in-out schemata,* wherein the structure provides space for intention. I tend to think of it as a drawing a face with minimal features. A circle for a head, straight horizontal lines for eyes and mouth, and inexpressive vertical lines for ears. Upon that I begin to add cracks and smudges to accent features, colour to lips to provide distinction and contour, etc.

In *Funerals,* we, the performers, started out with basic forms or ideas for the movements, and upon this we layered expressive characteristics that were genuine and authentic to our association to the instrument and most important, ourselves. This was done through experimenting with shifts in body weight to embody the form in space, causing friction between connections in the hands and fingers, or even experimenting with a pendulum effect to try to animate the connection between the hips and torso. For *Bodied Chambers,* Alessandrini and I isolated the basic structure while continuously referencing the theme of interference for clarity and to help strengthen the purpose behind creating the work. I used my hands to ignite sound material for vibrations in the transducer membranes and on the body of the cello; the voice to match and weave in

and out of the pitch center of the overtones which caused "knocking" sonic effect, and sporadically bringing the body of transducer "membranes" in and out of contact with the cello. This weaving created an action-feedback cycle that allowed one action to drive the next, as if melding into each other. In short, this process and project created a new way to sonify movement which enhanced the ecological structure constructed from the start.

The same principles that Kant, Johnson, and Forsythe suggest in the analysis of dynamics and separations of structure, both rich and expressive, are continually applied through critical research processes in the work developed with SINE QUA NON, Alessandrini and P. A. R. T. S. The process of reasoning and examining continues into my later work with digital musical instruments in Chapter 5. It's interesting to reflect on the beginning of this research and see the superimposed divide of disciplines, only to later see that there is a common linguistic thread that allows us as artists and researchers to share developmental processes regardless of deviations in comparable terminology.

PART II
Embodied and Sonic Expressions of a Digital Prosthetic

CHAPTER FIVE

DIGITAL MUSICAL INSTRUMENTS AND *ALMOST HUMAN*

> In an attempt to leave room for new developments, yet identify federating characteristics, one proposed working definition of the instrument is that of a system that is autonomous and open-ended. By autonomous we mean self-contained and self-sufficient. This could mean that audio content, sonic modification, and control interaction co-exist on the same device. By open-ended, we mean extensible systems. This could mean modifications adding to or enhancing an instrument's sonic characteristics. —Atau Tanaka (2010, p.88)

Part One of the thesis explored technical processes in segmenting and analysing movement that was informed by dance theory and notational systems. Part Two of the thesis explores the range and depth of performing with a Digital Musical Instrument (DMI), specifically the Spine which was developed and created at McGill University (CIRMMT/IDMIL research laboratories in Montreal, Canada) by Joseph Malloch. The forthcoming sections outline the artistic process of creating the experimental work for prosthetic DMI and cello, *Almost Human* (2014) which I premiered in London at the New Interfaces for Musical Expression (NIME) Conference. In discussing the process, I focus on the transformation of instrumental gestures, mapping the body and interface in real-time for expressive usage, performance with the Spine, and address the idea of 'Liveness' in interactive performance.

5.1 Digital Musical Instruments and their Innovators

Miranda and Wanderley (2006) define a digital musical instrument as 'an instrument that contains a control surface [also referred to as a gestural or performance controller, an input device, or a hardware interface] and a sound generation unit. Both units are independent modules related to each other by mapping strategies' (2006, p.3). The history of the DMI begins as early as the GROOVE system (Mathews and Moore, 1970) with precursors like the Theremin 'already displaying the key property of separating the control interface from the sound generation unit' (Lyon, Knapp, and Ouzounian, 2014, p. 64). 1984 saw the introduction of the MIDI protocol and commercial DMIs such as the Yamaha DX7, which was sold commercially. Most of the commercial DMIs of this period were conservative in design, but a few experimental interfaces such as Yamaha's Miburi could also be found. No longer would musicians only be able to hear sound, but eventually they would create personal instruments that would make it possible to 'touch' it as well. In a case study article on composing and mapping for the Biomuse,[48] violin and electronics, composer, Eric Lyon, states that a 'third stream of DMIs, developed since the 1990s, involves innovative focus on the performance interface and has centred around the NIME community since the early twenty-first century. Such DMIs can afford both performance and new potentials for musical interaction' (Lyon et al., 2014, p. 65). The appearance of new experimental innovations would later produce multiple conferences for creators to share and learn from colleagues with shared similar interests.

With the rising interest in interface development for performance, the first NIME Conference was created in 2001 and served as a haven for radical thinkers in design, programming and performance for electronic music. The NIME Conferences focus on

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48 The Biomuse is a muscular sensor band developed in 1987 by Benjamin Knapp and Hugh Lusted.

Developing novel or alternative musical interactions by merging together the principles, traditions and innovations from both Human-Computer Interaction and from twentieth century Western European concert and experimental musics…this work is not realised within a vacuum and inherits, intentionally or not, characteristics of the social, cultural or economic environments from which it emerges (Marquez-Borbon and Stapleton, 2015, p.1).

The framework of this community is made up of an aggregation of practitioners, performers,[49] designers[50] or composers,[51] that are looking for avenues to expand electronic music aesthetics, sound synthesis and expressivity through digital age lutherie. Yet, within this growing community, we are presented with a plethora of instrument prototypes which either lack a proper performative practice to show full capability, or longevity beyond demos and poster sessions at NIME and computer music conferences (ICMC-SMS). Artists who stand out amongst the community for their refinement in experimental instrument development, scholarship in disseminating technical advancements in software/hardware, and informative performance practice include: Michel Waisvisz, Laetitia Sonami, Stelarc, Atau Tanaka, as well as Julie and Mark Bokowiec. Their technical and artistic output has inspired my work with the Spine and future interface developments, as well as many other practitioners in the field.

The aforementioned artists working with DMIs have developed and innovated by way of constructing instrumental interfaces that not only focus on computational prowess and experimental design, but embrace the intimacy and beauty of truly expressive and musical performance. Of the artists mentioned, the work of Tanaka and Waisvisz align closest and have influenced the way in which I work with DMIs currently and my future work in the field. Atau Tanaka's earlier work with the EMG sensor bands

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49 An example of performer led research in the NIME community: Gaye,L., Holmquist, L. E., Behrendt, F., and Tanaka, A. (2006). Mobile music technology: Report on an emerging community. In Proceedings of the 2006 Conference on New Interfaces for Musical Expression, 22-25. IRCAM - Centre Pompidou.

50 An Example of current research on design on DMIs in the NIME community: McPherson, A. and Kim, Y. E. (2012). The problem of the second performer: Building a community around an augmented piano. Computer Music Journal, 36 (4), 10-27.

51 A recent example of composer and HCI-related research within the NIME community: Rambusch, J. (2006). Situated learning and Galperin's notion of object-oriented activity. In Proceedings of the 28th Annual Conference of the Cognitive Science Society, volumes 1998-2003.

and the Biomuse[52] have helped redefine the idea of muscular and expressive performance and pushed to enlighten dogmatic views of digital instruments in a way that allows them to be validated beyond being categorised as evoking 'virtualness'. His work with the Biomuse and performances with the interactive performance trio Sensorband,[53] and pianist Sarah Nicolls[54] amongst others, shows some of the possibilities in interactive performance that centres around the theme of physicality and human-interface control in relation to technology.[55]

Michel Waisvisz, Dutch musician, composer, and former director of STEIM in Amsterdam, took the electronic music world by storm with his invention and thrilling performances with his instrument, THE HANDS.[56] Through machine learning and the use of both sampled sounds and those produced through the early Yamaha DX7 midi synthesiser, Waisvisz was able to show expression, tactility, and physicality in his performances the same way one would observe in Rostropovich's 'gutsy' performance of Shostakovich's Cello Concerto No.1. These two artists, and those aforementioned all have different artistic practices and have created different interfaces to express themselves. The one thing that links artists such as Tanaka and Waisvisz together as a community is not the fact that their music is situated within electronic music, but their drive to create and develop an artistic and instrumental practice that challenges both cultural and artistic norms, and furthers technological developments for DMIs that are of use to both developers and performers in the digital age.

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[52] Reading on the Biomuse may be found here: Tanaka, A. (2015). Intention, Effort, and Restraint: The EMG in Musical Performance. In *Leonardo Transactions*, MIT Press, 48 (3), 298-299.

[53] Further information may be found on the Sensorband trio here: http://www.ataut.net/site/sensorband.

[54] Performance Collaboration between Atau Tanaka and Sarah Nicholls on the composition 'Suspensions.' Retrieved from https://youtu.be/hwVz54gb-kE. Last accessed on 24/7/2015.

[55] This is created by using Electromyogram [EMG] sensors that translate neural and muscular signals into digital data.

[56] Webpage for Waisvisz's The Hands. http://www.crackle.org/TheHands.htm. Last accessed on 24/7/2015. The first performance of The Hands was in June 1984 and was built at STEIM and controlled three Yamaha DX7 midi synthesisers.

5.2 The Spine

'…The spinal column is nothing but a sword beneath the skin, slipped into the body of an innocent sleeper by an executioner' (Deleuze, 2005, p. 17).

The Prosthetic Spine is part of a family of digital musical instruments (DMI) designed to be used for interactive performance. Alongside The Spine, this DMI family includes: The Visor and Ribs, and are able to be worn as attachments to the body as well as detached and used as handheld instruments. These instruments were originally developed for the interdisciplinary research project and dance concert, *Les Gestes*, that included participants Sean Ferguson and Marcelo Wanderley of McGill University, violinist Marjolaine Lambert, cellist Elinor Frey, as well as Isabelle van Grimde and her dance company Van Grimde Corps Secrets. After attending the performance in Paris I noticed a distinct lack of interaction between the instrumentalists and the instruments. Afterwards, I began researching the possibility of integrating the instrument and movement together to create the meta-instrument that drew upon Western instrumental performance and my background in both dance and movement.

The development and manufacturing of the Spine along with its siblings created specific and unusual demands on the designers Ian Hattwick and Joseph Malloch due to them having to create a finished product that could be used by technical and artistic staff as well as being fitted to the dancers to complement their movements. Early DMIs had novel DIY designs that would normally be used by the creator or a selected performer. In the case of Hattwick and Malloch, they were designing for the stage and specific performers, which requires hours and hours of designing, prototyping and adjustments until a final product is available, so that a polished product that was artist-specific would be the best option in creating new digital instruments. The designers state,

> We conceptualised the Prosthetic Instruments as "hypothetical" prosthetics, not replacing a pre-existing limb or body part but rather functioning as a potential new body part. To be believable as hypothetical prosthetics required that the instruments integrate well into the aesthetics of the dancers' bodies, move well with their existing limbs, and attach securely to the dancers bodies with also being detachable in performance (Hattwick, Malloch and Wanderley, 2014, p. 443).

Hattwick and Malloch's developed process is unusual to the NIME community in that these instruments needed to be ready for use by professionals and they were fortunate to have the collaboration of dancers that were willing to provide instant feedback on what was needed. This could be seen as Artisanal design built to "artist-spec" as Bill Buxton describes at length in his article on designing interfaces for artists (Buxton, 1997).

5.3 The Spine Electronics and Mechanics

The electronics for the Spine is based on two 'Mongoose 9DoF Inertial Measurement Unit (IMU) boards, one located at the head and one at the tail. Custom firmware was written for the Atmega processor on the Mongoose boards for sensor fusion and communication with an XBee radio modem also located in the tail' (Hattwick, et al., p. 446). The location of these IMUs allows for complete orientation of the head and tail which affords recognition of the twisting and bending of the Spine. A lithium-ion battery powers the IMUs and XBee and lithium-ion AAA batteries control the two LED flashlights mounted directly in front of the sensors in both the head and tail of the Spine. Later in my research development, a separate circuit board was created just for the lights, as one battery powering both the XBee and LED lighting was not enough and affected the accuracy of the mapping in performance.

The physical Spine is made of 1/4'' thick triangular acrylic vertebrae that is threaded onto two PVC hoses that form what the designers describe as a 'a truss-like structure'. In between the form of the Spine is a third rail that consists of a narrower

PET-G rod that is fixed to both the head and tail of the Spine, causing a convex curvature at the head and a concave curvature towards the tail. Small soldering adjustments were made by Hattwick and I once I began work with the Spine as length and height placement of the truss was too short. The PET-G rod was also cut down and readjusted to fit my frame because the dancers it was originally designer for were shorter than I (see images in Figure 17).
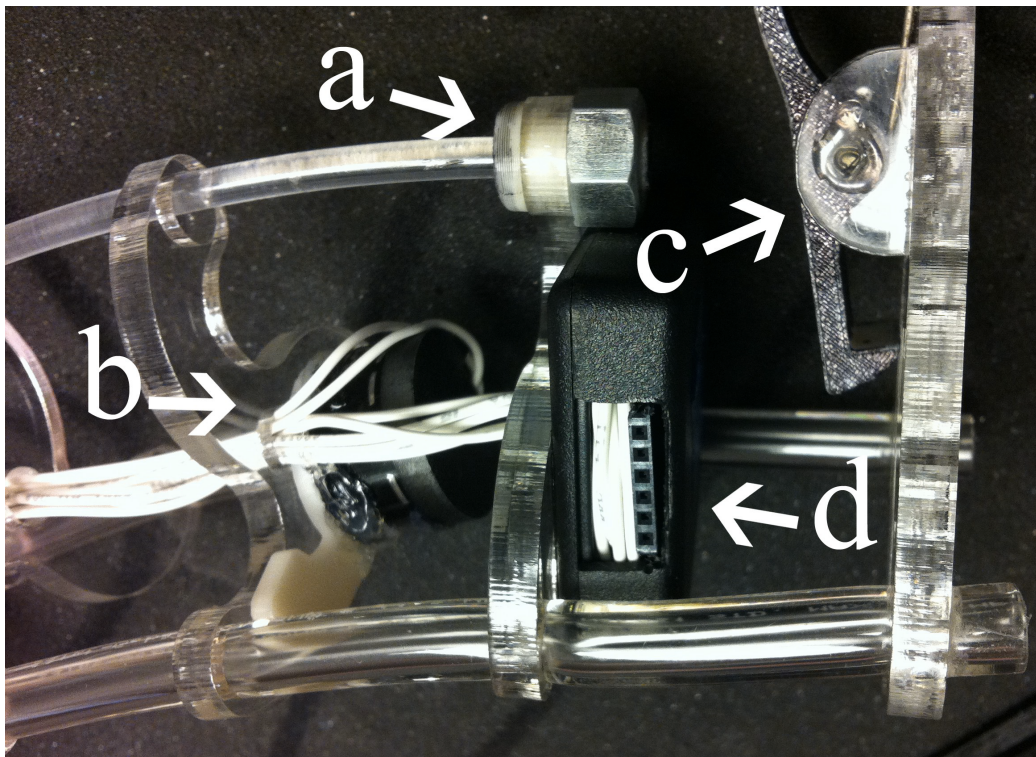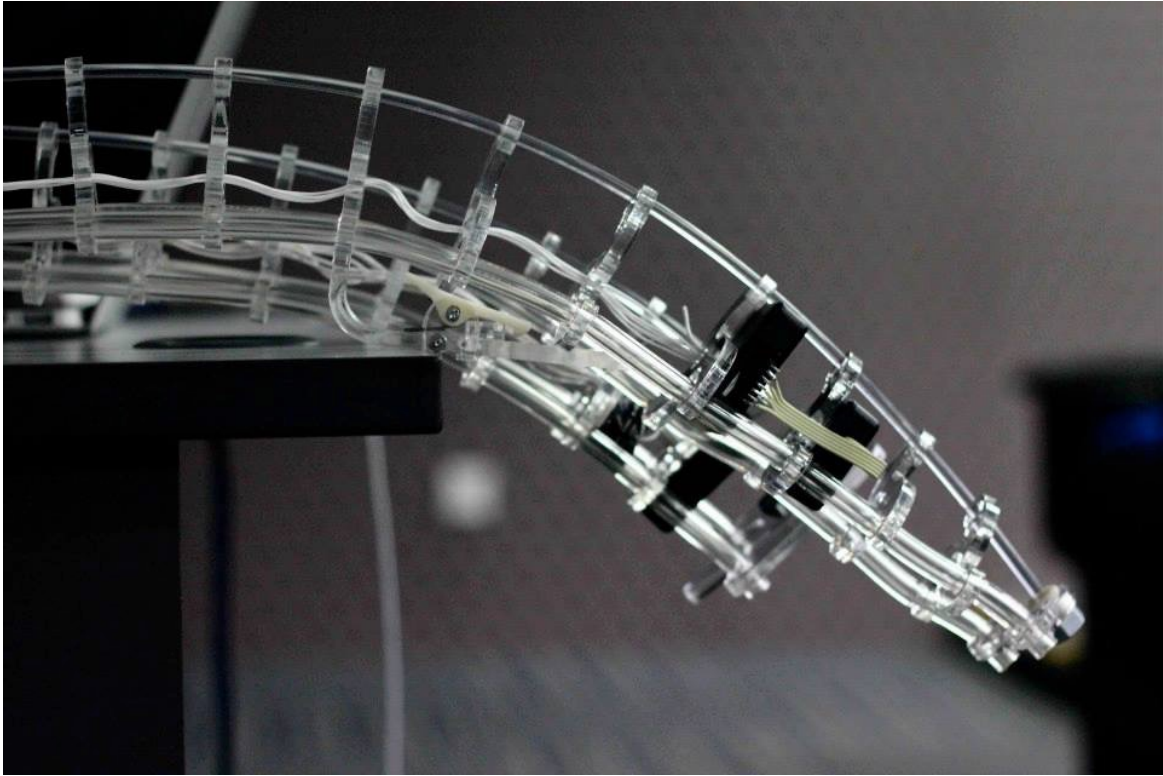
Fig 17: Portrait and profile angles of the Spine, as well as the head of the Spine. Labelled are a) the PET-G rod in its mount, b) the LED lighting with its mount, c) the clip for attaching the mount on the back of the headband worn, and d) the enclosure for the head's IMU.

5.4 Almost Human

5.4a Early Sessions

The collaborative research and creation phase of *Almost Human* between Hattwick and I took place in the CIRMMT Lab at McGill University in 2013. I met with Hattwick to discuss aims and goals for the possible piece that would come out of this process, as well as finally deciding on which of the instruments to use. The Spine was the easiest to move with and required little adjustment in shifting from dancing to playing the cello. I believed that the integration of cello and Spine would be successful without any glitches, but the research phase would be the final test . To be clear, my initial understanding of the family of instruments in the beginning was little to none, and Hattwick was the "expert" in knowing what its possibilities were. However, neither of us had ventured into this form of creation so a collaborative process needed to be created to find an integration.

Although there are many methodological examples of working with dance and interactive systems (Bevilacqua, Nagle and Valverde, 2001, Winkler, 1997 and 1998, and Siegel, 2009), none addresses the specific situation of musician and dancer playing both roles simultaneously, being as one. Rather than attempting adaption, therefore, I chose to devise a new methodology that presents a full performative integration of musician, dancer and interactive system. As I am a cellist, my initial approach was to transfer my tactile understanding of playing the cello to the Spine. This proved difficult and in many instances unsuccessful due to the Spine's lack of resemblance to the cello in design, tactile sensation, and sonorous output through interaction. This revelation forced me to reevaluate my approach to movement, sound production and eventually composition.

In composing as well as performing, beginnings tend to start from silence and it is that silence that gives birth to the music and allows one to factor in space and even timing in the traditional sense. On the one hand, this hints at a Cagean existence of

silence, where there is the opening up of the 'impossible inaudible' (Kahn, 1999, p.

160), but one should not diminish the role of bodily interaction in sound production due

to its constant vibrating state even when labile. The connection to Cage is not there to

suggest the work with the Spine is created in silence, but acknowledge, just as Cage

had, that all matter was constantly in a state of vibration (Kostelanetz, 1987, p.106).[57]

Nicholas Brown states that 'The normal process of living engages our plurality of senses

and Cage did, on occasion, speak about a need in making art for "kinaesthetic

sympathy" (Cage, 1973 [1961], p. 65), in particular for the use of the whole body in

perceiving and creating new dance'(Brown, 2006, p. 40). As Douglas Kahn writes (1999,

p.164), Cage 'formalised the performance of music to where it could be dependent on

listening alone, …He opened music up into an emancipator endgame.' Through the use

of technologically assisted music, the endgame inevitably 'spawns the task of

transcending what David Toop (2004, p. 2) has recently called "the disembodiment that

comes with the digital world"' (Brown, 2006, p.40). Silence is then able to give voice to

even the smallest of sounds, but only by eliding physical movement to produce a sound.

By embracing the movement I had the possibility to use an electronically assisted

instrument and give voice to sounds I had only previously embodied. This fascinating

instrument was the perfect tool to explore the seen/unseen, and the heard/unheard.

Presented with an instrument with a short performative practice, Hattwick and I

searched for an entry point to build a language and eventually a practice, both

compositionally and performatively. We used a voice sample from Alfred Hitchcock's *The

Birds* (see speechspine1/speechspine2 video) to help me ascertain the instrument's

capabilities. In doing so, this media operated as a fixed score which I could manipulate

with my movements, and drive the Spine to pan back and forth in the input sample. The

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[57] In this conversation, Cage states 'this table, for instance, around which we're sitting, is made
    experiential as sound, without striking it. It is, we know, in a state of vibration. It is therefore making
    a sound, but we don't yet know what that sound is.'

Hitchcock sample is referred to as a'fixed score' due to the lack of possibility to add more material to it. As the performer, I am only able to manipulate that which is already there by either increasing or decreasing the playback speed or panning in between segments of the file, which creates a stuttering stagnation as well as the actors pitched voice (see Speechspine1 00:28-31 for an example of vocal manipulation). In hindsight, I could have started by handling the Spine as a controller to understand the physical parameters on which it operates. Nonetheless, having it attached to me via the head and tail created a useful learning curve. By improvising with a 'score' I learned the limits and initial breaking points of the Spine's mapping, based on a parameter that was initially set up.

5.4b Transformation of Instrumental Gestures

Following the initial exploration with the Spine, Hattwick and I revisited the original series of gestures that were created from the case studies. Many of the gestures that were categorised were useful for the sake of segmenting performative processes in contemporary practices, but proved not as useful in the choreography. I went through a phase of redefining the meaning and intention of each gesture and trying out new transformations of the original movements. The first attempts resembled 'air-cello' but eventually segmented movements were found that resonated with the original embodied gesture; albeit a better full body translation. Continuing to address each gesture from Trajectory, Repetition and In Extension (as discussed in Chapter 3), conceptual movements were formed that were of a closer resemblance to the instrumental versions. The development of the entire dance structure would follow.

Three sections of the dance were created with the Spine that featured a series of fleeting impulses from the original gestures, but masked through transformation. The

transformation of gestures was difficult because I was used to performing in an instrumental manner, but this process forced the re-evaluation of my understanding of effort, intention and space. The process included improvising on stagnant gestures, which is a frozen image of the entire movement. I explored the energy of each gesture in question, observing and responding to the embodied sensation. I was no longer seated in a chair but surrounded by ample, unobstructed space, and I began questioning the amount needed in order to create the movement. It is possible that the final evolution of the gesture was not a new one but a fleeting moment that could clearly link another articulated gesture. Drills were created to test fluency in the movement, from recollection of drawings to actual interpretations of them, and clarity in understanding the intention behind the new choreography. By creating a conceptual idea of the new movement, I could repeat it until a cohesive form of that gesture was shaped, which was executed in the same fashion as practising scales for fluency and development of muscular memory.

5.4c Mapping

Once the gestures were redefined, Hattwick and I began developing an interface route between myself and the computer to control the electronic score that was being built. Hattwick recommended we use the machine-learning software, The Wekinator (Fiebrink 2009), which was created by developer and researcher Rebecca Fiebrink. Created during her doctorate at Princeton University, Fiebrink created a software or 'meta-instrument' as she describes it, 'which allows musicians, composers, and new instrument designers to interactively train and modify many standard machine learning algorithms in real-time' (Fiebrink, 2009, p. 1). Since Hattwick and I were operating under a strict schedule, the Wekinator would be the best option for quick and 'on-the-fly' programming. With the Wekinator, we fed the machine gestural inputs whilst I wore the

Spine in real-time, which helped continuously train it to register the movements, and use the 'output of the learning algorithm to drive sound synthesis in the environment of her [his], she [he] may assign the output some other function' (Fiebrink, p.1). The Wekinator doesn't create complex algorithms, but by constantly updating the set of gestural inputs, a more complex model can be created that would eventually be used for both mapping the dance movements in space and also for interfacing sound synthesis with MAX/MSP (Cycling '74) and Ableton.

The gestures were input into the Wekinator without the cello and a useable model was generated to create parameters for movement recognition and the manipulation of the sound synthesis that would later be created from both the cello score and dancing. Since I would barely be using the Spine as a hand controller, and more of a full body controller, three parameters (X,Y, Z axis) were configured to help in assisting with driving sound creation. Early trials of training the Wekinator proved both successful and unsuccessful. Some inputs failed in recognition of a specific gesture or parameter calculation in the first trials, and others excelled. Though this form of machine learning is a quicker process than other ML systems, the constant act of re-inputting data can be laborious. Eventually, a trained model was created that contained feature and parameter pairs, which are recognisable by designated gesture and parameters, a dataset that was interfaced with Max which would register bending, twisting, sitting, jumping, head spirals, as well as neutral movements and adapt it to reflect quite minimal, expressive, or radical movements in real-time through user control (see Figure 18).
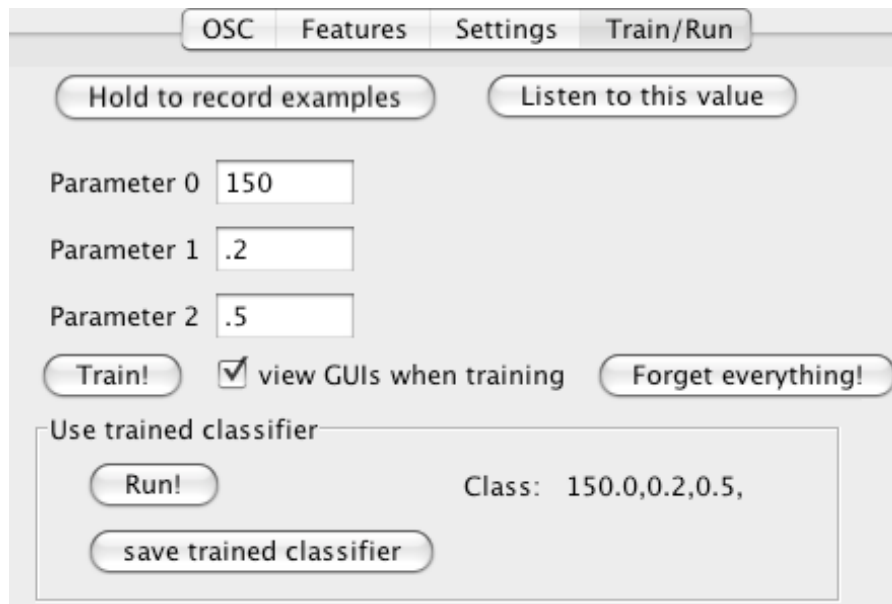
Figure 18: GUI pane for training and running (NN mode, three output parameters) in the Wekinator software.

5.4d Technical Design and Functionality

Almost Human utilises several different approaches to sound synthesis. The primary electronic elements utilise two different approaches for real-time manipulation of pre-recorded sound files from extracts of the cello score — granular synthesis and phase vocoding, and was designed by Hattwick with collaborative feedback from me.

The granular synthesis implementation is based on the granular toolkit by audio artist and researcher, Nathan Wolek (2001, p. 34-36). In this process, audio is stored in a buffer and then a large number of sonic 'grains' drawn from the buffer are played back simultaneously. These grains are between 10-200 milliseconds long and can be played back at various speeds to alter their pitch. The location of the buffer from which the grains are drawn has a large impact on their sonic quality. By varying the audio file stored in the buffer and the playback location, speed, length, density, and amplitude of these grains, a wide variety of effects can be achieved.

Phase vocoding, which scales frequency and times of a signal utilises a short term

Fourier transform (STFT), to determine the amplitude of the frequency components of a short segment of audio, a process which is commonly described as 'moving from a time-domain to a frequency-domain representation of a signal' (Hattwick, personal communication, August 2, 2015). Once in the frequency domain, the frequency components of sequential segments of a sound file allow for the sound file to be reconstructed at varying speed without altering the pitch, or even to freeze a sound file at a specific location. The phase vocoding algorithm used in *Almost Human* is based on an implementation by Richard Dudas and Cort Lippe, who also present a more thorough description of the phase vocoding algorithm (Dudas & Lippe, 2006).

In addition to these two algorithms, additional sonic treatments including zero-latency buffer based convolution, comb filter, and physical modelling techniques are used. The convolution algorithms utilise Max/MSP objects that were created by composer and diffusion artist, Alex Harker; two physical modelling synthesisers in Ableton Live, Collision and Tension, were used to create background sonic textures.[58] In addition, a mesh physical model by John Gibson is used as a delay effect.[59]

In correspondence with Hattwick about the functionality of the sensors in the spine, he states, 'Four basic control signals were derived from the sensors in the spine. Three describe the relative orientation of the Magnetic Angular Rate and Gravitational (MARG) sensors located in the head and tail of the spine. Using these relative orientations we can sense bending of the spine, distinguishing between flexion, bending the head towards the waist, as well as lateral bending, and twisting of the head in relation to the waist. The fourth signal is the overall magnitude of movement of the

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[58] The Collision instrument is a physical model instrument in Ableton Live used to recreate authentic and creative percussion sounds. More information on Collision may be found at: https://www.ableton.com/en/packs/collision/. The Tension instrument is a physically modelled, and highly accurate string synthesiser that reproduces stringed instrument sounds or even hybrids, as is the case for use with the Spine. More information may be found a: https://www.ableton.com/en/packs/tension/.

[59] Information and examples of the convolution algorithm may be found at Harker, A. and Tremblay, P. (2012) 'The HISSTools Impulse Response Toolbox: Convolution for the Masses'. *In: ICMC 2012: Non-cochlear Sound.* The International Computer Music Association, 148-155.

spine, which consists of the sum of acceleration of both MARG sensors.'[60] In designing and designating local parameters for these specific sensors, the ability to monitor single or multi-layered movement, as well as physical and sonic latency is possible.

Almost Human is composed of two main sections — cello performance and dance performance — and three subsections. Each sub-section within the piece uses a different combination of the synthesis techniques described above. The initial section features the cello with light electronic treatment. The electronic treatment uses a live cello signal that is stored in a buffer which is read by the granular synthesiser. The signals from the Spine alter the parameters of the granular synthesiser in subtle ways, while the amplitude of the cello signal is used to duck the amplitude of the electronics. Ducking in the context of this work means to control the volume of one audio file by the volume of another.[61] When the cello is playing at a high amplitude it lowers the amplitude of the electronics, and when the cello is quiet the electronic's amplitude is increased. In this way when the cello is playing loudly there is little electronic sound competing with it, and when paused the electronic sound fills the gaps.

The first sub-section utilises the granular synthesis based on a pre-recorded audio file of my cello playing, as well as the Collision virtual instrument in Ableton Live, which is used to create background textures. Within this sub-section are cues that were created to change the location within the audio file which is used to generate grains in the granular synthesis. The synthesis is then fed into the mesh delay and then into a convolution reverb. The control signals from the spine continuously interpolate between multiple parameter presets as well as controlling the delaying times in the mesh physical model based within Ableton Live.

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[60] In the Max patch for Almost Human flexion is annotated as BendX and BendY.

[61] Ducking is commonly used to describe dance tracks where the bass drum plays the rest of the track lower in volume to achieve a 'pumping' effect.

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The second sub-section utilises the phase vocoding of a prerecorded sample of a sustained flute overtone moving through different harmonics. The use of this sample allows for clear mapping, gesture following and manipulation through flexion of the Spine. Flexion of the Spine controls the location of a small subsection of the flute recording used for re-synthesis. To prevent a static re-synthesis of a single fast Fourier transform (FFT) frame, which is a computer-based algorithm for analysis and synthesis, a low-frequency oscillation (LFO) is used as an additional modulator for the phase vocoder location.[62] The depth at which the LFO functions is controlled by the twisting of the Spine. In addition, a very low level of the Collision virtual instrument is once again used to add further sonic depth.

The final sub-section is similar to the first, albeit a different audio recording of my playing is used as the basis for the granular synthesis. Additionally, the Tension virtual instrument, a string synthesiser, is layered onto the Collision instrument.

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[62] The LFO is is designed to produce low or below the audio range frequency signals, in effect creating a sort of vibrato effect within the synthesizer.

Almost Human
for Seth Woods

Ian Hattwick

Figure 19: Excerpt of First movement of *Almost Human* (2014).

5.4e Compositional Mapping

> 'The mnemonic and reproduction need for writing down what to play has gradually become a goal in its own right. All too often I've seen how fellow-composers have been more excited by how the "music" looks than by the way it sounds' (Waisvisz, 1999, p. 121).

Composed of two sections, the first section features the cello with performing music inspired by the previously discussed solo cello works with live interactive electronics. The second section features the performer dancing with the Spine. In section one, Hattwick created a cello score that would both reference selected instrumental and expressive gestures from the ten case study gestures discussed in Chapter 3, and use

them as expressive material that I would later manipulate in the second section. By creating a new translated movement score, the cellist acts as the puppet and puppeteer in the piece, indirectly mimicking himself as well as manipulating the sound that is derived from the movement. Although the original material comes from various composers, the important extracted material, which will be discussed shortly, is derived and inspired from my performances.

The notation used for composing the written cello score serves as a framework of movement sonification, whereby the performer approaches this score as a movement notation instead of a sound score, as is the case in Western performance practices (see Figure 19).[63] In the case of the score I was less concerned with what was notated in regard to pitch material, and more with the movement that influenced the writing from section to section. This section shows how the original extracted gestures are used to create sound material in the form of a score, which then supplies sonic life to the prosthesis.

With regard to mapping there are several aspects. First is the choice of sensor, in this case the IMU boards located at the head for the first section, which together with the first instrumental attack, triggers the official start of the first movement and initiates the mixed spatial reverb, delay and input processing of the cello, and it also time stretches the harmonics. The IMU board at the head was chosen after looking at MoCap sessions and noticing a large degree of amplitude coming from head movement. Assigning mapping and triggering control to the head would be the easiest and subtlest way to allow for interaction from the performer outside of the active movement from the arms and hands. The second aspect of the mapping is the choreography of the

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[63] These practices are related to instrumentalist's reading symbols and signs that have a related sound. Although, in order to create them, an action must take place. My personal understanding is that some musicians do not approach classical music scores as reading movement but sounds, and for me, this score is a representation of movement instead of pitches, due to the material having been derived from gestures.

gesture, which is devised by the performer. The third aspect which adds to the successful mapping throughout the work is measuring bow pressure, velocity, vibrato frequency and position, as well as using sampled sound files of the score to create physical modelling of the cello score and expand the harmonic spectrum within the MSP environment (see Figure 20 for the Wekinator bowed patch in Max/MSP). The last aspect helps shape transitions through capturing pitches and gestures created by the performer and using it to segue to the second movement (see AHV 1:08-:36, 1:40-:50; 2:34-3:00 for these technical sequences).

Two significant gestures from the gesture taxonomy which begin and transition the first movement are discussed below. It is worth noting that all the musical material performed on the cello is stored in a buffer which is later 're-performed' and processed in real-time while dancing with The Spine. The Spine's interaction with the electronics in the first section, however, is minimal due to a rather 'fixed' performative state needed to input and perform the musical material. There are few moments where there was the possibility to sustain natural harmonic pitches by oscillating the head. Based on the MoCap session and early trials, Hattwick and I noticed that the head would be the only useful ligament that I could use to provide minimal interaction in the first movement, due to me being seated and my hands and torso engaged. Therefore, it was decided that I would maintain fixed movements so data being sent to Max was as pure as possible because it would later be used for the second movement.
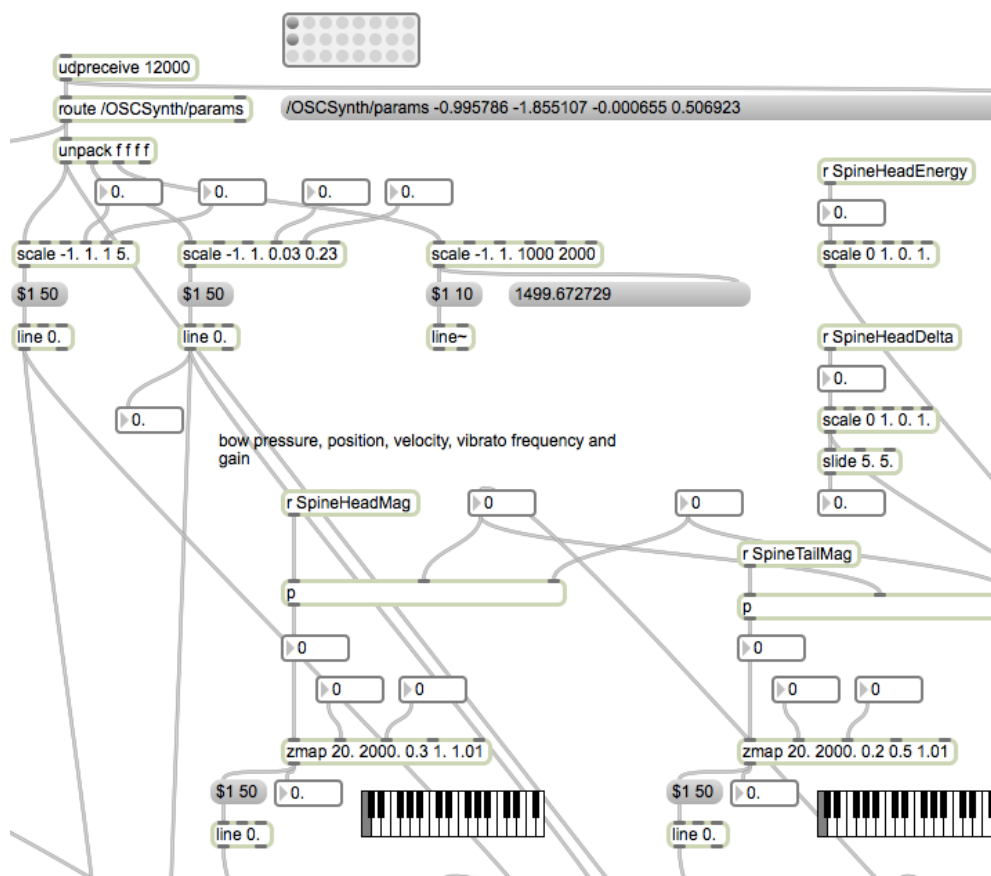
Figure 20: Wekinator Bowed patch in Max.

The first gesture performed on the cello occurs in first measure of the first section (see Figure 19). This gesture begins with a heavy accented *forte* expressive indication on an A-flat and is followed by the sustained 'E' in fourth position which morphs into a tremolo. This gesture is a compositional hybrid and translation of two original gestures from Hamel's *Grey Neon Life* and Gabriele's *PNOM*. The initial strike at the beginning of the measure is the Impulse gesture (number 8), followed by the float-rotate-lift gesture (number 2). The Impulse gesture is the first sampled sound bite that is recorded into the buffer for later use in the second section. Visually, it is a very striking action that is perceived by the audience, but in conjunction with the electronics, there is a delay in its sounding (0:05 in the performance video) from the initial attack. This is due to a parameter setting and granular synthesis in Max. The accented attack begins the first

environment which includes the oscillation of processed chapel bells whose levels are controlled and interfaced with the Ableton Live physical modelled synthesisers. By syncing the mapping with Ableton, bow attacks, upper-body movement, volume control and changes to sonic environments become more stabilised due to their reliance on active movement for guidance.
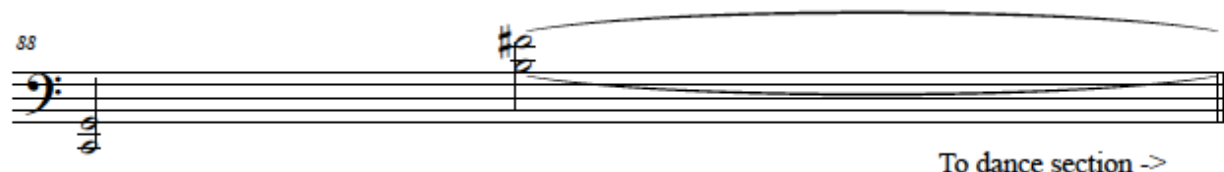

Figure 21: Excerpt of *Almost Human* score referencing the Impulse gesture.

The second gesture occurs in the last bar of the score — measure 88 (see Figure 21). Translated once again from the Impulse gesture of Hamel's *Grey Neon Life*, Hattwick captured the trace-form movement from the second beat of that gesture, which is an elongated but quick glissando with a pizzicato accent at the very end. In this score, Hattwick creates a strong accent on beat one in measure 88 that crescendos to beat three. On beat three, the performer creates a strong whipping attacking of the harmonics that also samples the chord.[64] The sampling is initiated via an articulated head movement and triggered by a cue in Max (see 2:31-:34 in AHV). This last gesture not only serves as a dramatic closing of the first section, but also helps segue into the next by sampling and sustaining the pitches that are then faded into the granulated texture.

Many more gestures were mapped onto the Spine and will be discussed in the next section involving choreographing with and without the Spine.

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[64] My description of the harmonics differs from the notation. Hattwick notated the pictures with actual note-heads in stead of diamond symbols to indicate natural harmonics. This was later clarified in discussion.

5.4f A Choreographer's Score

In interactive dance settings that employ more than one creator, a division of roles must be acknowledged and set. In most cases there is a composer, a choreographer, and a dancer. In some cases the dancer performs to a fixed musical score and realises the structure and form of the choreographer with little interference with the diffused music; all the while trying to synchronise their movements to it. Yet, what happens when the situation is reversed and the dancer is finally asked to 'dance the music' rather than dance *to* the music? The shift in creative roles allows the dancer to not only realise the structured choreography, but also control some, if not many, of the live sound processing or manipulation characteristics of a performance that are typically done by the composer or a fixed tape.[65] *Almost Human* is one current example where the choreographer and dancer are under the same umbrella, working to sculpt the visual and sonic environments in an interdisciplinary piece where art meets science meets technology.

The second section of *Almost Human* focusses on a combination of choreographic and kinaesonic constellations.[66] The term 'kinaesonic' is composed of a compound of two words: 'kinaesthetic,' which is the movement principles of the body and 'sonic,' obviously meaning sound. In relation to interactive technology and performance, 'kinaesonic' refers to physicalising sound or mapping sound to movements.

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[65] Examples showcasing the shift in artistic roles can be found in:
Siegel, W. (2009). Dancing the music: Interactive dance and music. In Dean, R. (Ed.), *The Oxford Handbook of Computer Music,* Oxford University Press: Oxford, 191-201;
Siegel, W., & Jacobsen, J. (1998). The challenges of interactive dance: An overview and case study. *Computer Music Journal,* 29-43.
Winkler, T. 'Making Motion Musical: Gesture Mapping Strategies for Interactive Computer Music'. *In the Proceedings of the 1995 ICMC,* 261-264.

[66] Kinaesonic's is a term original coined by Mark and Julie Bokowiec in relation to their extensive work with the Bodycoder System (1995) and deals primarily with the one-to-one mapping of sonic effects of bodily movements in interactive performance. Julie explains that expressive qualities of kinaesonic alter from moment to moment based on locations of processing parameters such as pitch and colour. More information on the Bodycoder and Kinaesonic may be found at: Julie Wilson-Bokowiec & Mark Alexander Bokowiec (2006). Kinaesonics: The
 intertwining relationship of body and sound, Contemporary Music Review, 25:1-2, 47-57.

Constellations for the sake of this project, refers to spatial mappings and groupings of movements in a space. Kinaesonic constellations is therefore taken to mean the physicalisation of sound in space. In this section, I discuss the design of the choreography for the second section of *Almost Human* while covering topics dealing with mapping sound to movement and liveness while manoeuvring through a rather complex MSP system and environment as choreographer and dancer.

Throughout the thesis, the analysis of movement has been at the forefront of discussion as it relates to performance practices and ways to heighten a performer's (inter-) subjective relationship with their instrument and in participatory group settings. The focus revolved around inward reflection on movement, intention, time and effort, yet very little space was given for the larger observational aesthetic. Choreography's usual space, as argued by Belgian choreographer, Anne Teresa De Keersmaeker, 'is the frontal space of the theatre, which establishes a relationship in which the audience is fixed and the movement happens onstage. And the time of a choreography's unfolding is a framed time: a performance starts at a given time, say 8:00pm, and ends an hour or so later' (Filipovic, 2015, p. 1). *Almost Human,* was based on a rather structured performance time frame, although the exact minute to minute detail was never measured. Additionally, the conceptual scenography of the work was envisioned to take place in either a black box or theatre in-the-round. This way the contact with the audience is much more intimate and personal. Too often there is a separation of audience and performers in the arts, and subconsciously Hattwick and I aimed to create a haven that would afford the audience an experience of feeling, hearing, and seeing the sonic and visual formations.

Once the compositional score was created by Hattwick, I began devising a structural form that would loosely mirror the gestural influences of the cello score. It should be noted that the choreography was created originally without having heard the

electronic counterpart or using the Spine. This was done so that there was little

hindrance in movement possibilities or artistic trajectory; adjustments were later made

to connect the two. With the score in hand, I analysed it to draw a clear association

between the expressive gestures discussed earlier that influenced Hattwick's

composition. Doing this allowed me to pinpoint exactly what themes were embedded

within and what would be included or discarded in the choreographic process. From this

process, the following main themes would serve as the overall gestural structures of the

dance section:

1. Trajectory + Extension
2. Embrace +Doppler + Extension
3. Oscillation (Figure 8 rolls)

Each theme represents a series of one or two of the gestures in space. The occurrence

of each gesture was plotted as eight highlighted events, with the last three being a

'Chipotage,' which is a fragmented mixture of previous ideas. These plots serve as goal

'markers' that are filled in with segmented quotations of both simplistic and complex

forms of the instrumental and ancillary gestures. Keeresmaker states that 'usually, a

dance performance brings the layers accumulated in the rehearsals together,' and with

Almost Human, I choreographed in a way that afforded the possibility to see the

simplicity, the beauty of the movements that would suggest infinite combinations later

(Filipovic, 2015, p.2).

As stated earlier, the choreography was created without the influence of the

electronic score or the Spine for fear it would wrongly influence the movement or

artistic trajectory. The decision was made after reflecting on the motion capture

sessions at McGill University. In those sessions, I found that viewing the live video of the

performances prior to playing it influenced the next take, which made it slightly less

authentic and in the moment. Therefore, the same idea was used in developing the work

with the Spine. Choreographing and creating the work without the sounds allowed for an open plane for experimentation on what was being felt and heard without the influence of an additional score, which would have definitely guided the artistic progression. Isolating the development of the choreography alone strengthened the overall concept from an 'acoustic' standpoint. Had the Spine been introduced from the beginning, a different choreography might have been developed that catered more to what the instrument wanted and was capable of, instead of what the body and the choreographer envisioned.

The dance section begins where the last accented notes of the cello occur. From there, I, as the dancer, segue down-stage, centering myself in the middle of the constellation. All consequential movement afterwards will work outwardly from that point or encompass it (see sketch of choreographer's score on next page, Figure 22). From the score, the first movement represents the Doppler gesture which has been transformed as a sort of sweeping movement that propels and encourages the head to follow the momentum and inertia of the hands. This movement then develops into a variation on the gesture, but with the conceptual idea of fighting an invisible interference in the encompassing space. The movement stagnates and releases itself only to then push it towards the second marker, which is the Impulse gesture. Little time is spent here to give the illusion of fluidity and to avoid rigidly outlining every gestural marker within the structural formula. All subsequent gestures afterwards are treated as a kinaesthetic feeling of fleeting states. This is to say, that each marked gesture melds into the next one.
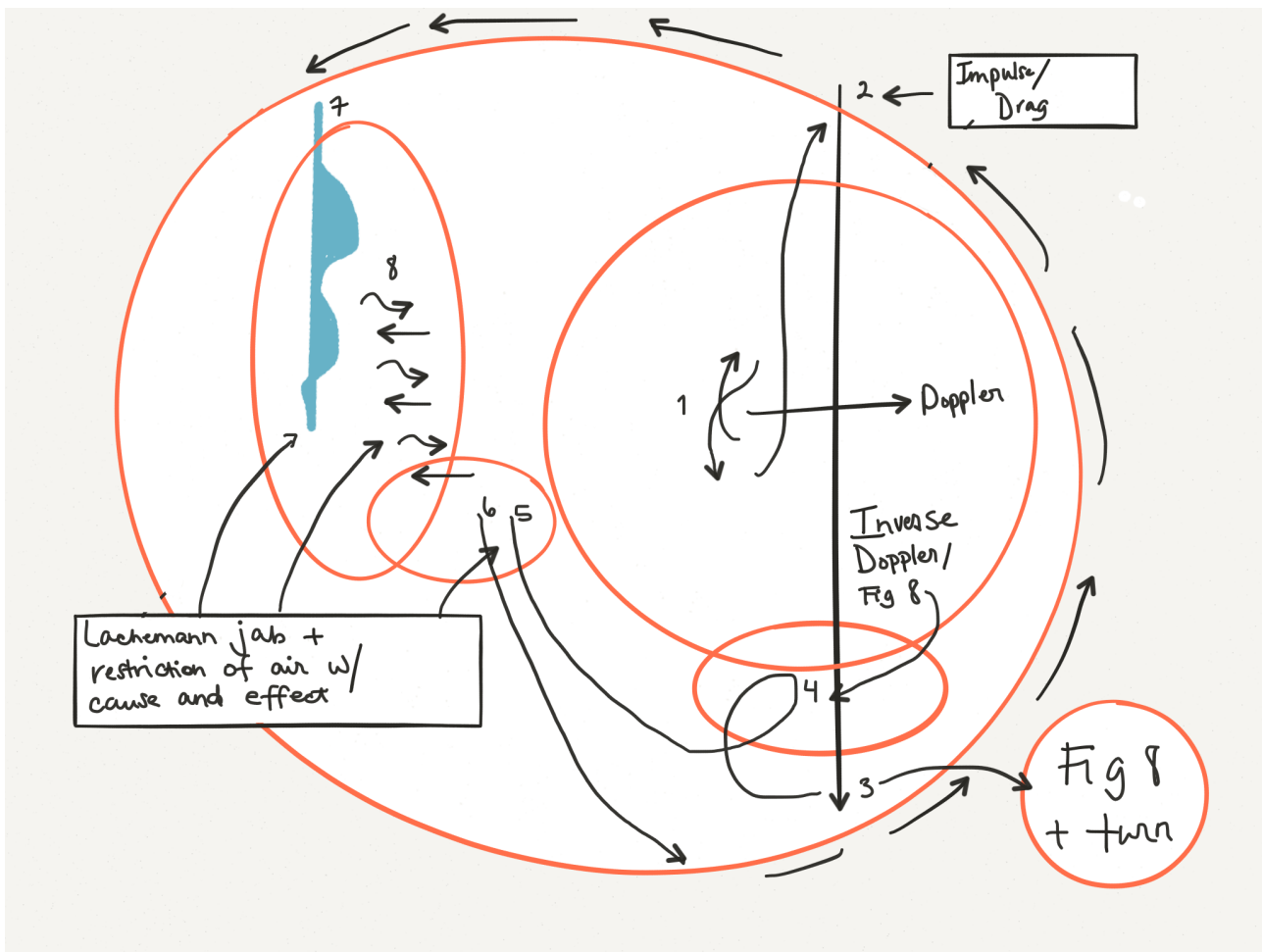
Figure 22: The choreographic score for Section 2.

The effort and energy needed to create these transitions illuminates an underlying tension and release idea in the dance. The physical flow from the second to third gesture creates a parallel dissection of the sphere of the first to create a visualisation of dragging the body from one pole to the other through clearly marked impulses, using the theme of Francis Spufford's sea odyssey as inspiration. From the third to fourth gesture, which is the Figure 8 roll to an Inverse Doppler with an Extended suspension through an elongated body, the length of space travelled and the clear articulation of the original gesture is truncated and shortened. By shortening the time and movement, only glimpses of the full choreographic line are presented and the result is an internal sound suspension in the body. The sound suspension is an initiation of the action that starts or reiterates a sound that becomes suspended as if slowly passing it off

to a future movement that has yet to be revealed.

The fifth and sixth gestures occupy a small constellation of their own which represents quotations of the Figure 8 roll, Doppler, and most importantly, the 'jagged scrape' gesture with the left hand in Lachenmann's *Pression*. This sequence is a loose translation from the musical score that is annotated as a stagnant line with brisk interruptions that fade back into the texture. The scrape occurs in gesture five and is presented and repeated on both the left and right side of the body through the causality of a pull and follow action that is initiated by the hands (see AHV from 5:40-54).[67] Through repetition, the left hand shifts from being an instigator of movement to the result which morphs it into the 6th gesture, also referred to as 'Team of Hope'. The sixth gesture is based completely on stilted movements, as if the body is stuttering. The dancer slowly explores the restriction of the action by attempting to complete the full range of motion of the gesture, which causes the dancer to orbit the entire space. Once the dancer has reached the seventh marker, the restriction in the environment has lessened, allowing a full and open range of motion.

The seventh and eighth gestures are miniature representations of the previous gestures all combined (see AHV from 6:10-7:20 to view the sequence). It is here even more than the other sections that there are intersections of dense and compact movement patterns, and the sounds that inspired them. The trajectory between seventh and eighth gestural events is to find a way back to the first sphere, where the journey originally began.

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[67] Another way to think of this is a cause and effect action.

5.4g Liveness and Kinaesonic

> "I don't know what 'live' means anymore (November 15, 1995). If the composer is performing on stage, what decision can still be made about the composition during its performance? How in the heat of the moment does the decision-making process deal with its simultaneous responsibility for both the composition and the performance? Isn't the performance both physical and mental? Isn't the composition both physical and mental as well?" (Waisvisz, 2009, p.120)

With the choreography finally set, the Spine and electronic score were incorporated. The first run proved slightly problematic due to the fact that the causality of the choreographed gestures and output sound were not completely clear. Movement with the Spine either yielded little to no corresponding electronic interaction, or the kinaesonic result was too extreme in comparison with the movement. It was not merely a matter of the choreography not fitting, but adjusting the sound processing parameters to draw a stronger visual to sonic connection that is more believable for both the dancer as well as the audience.

This issue in connecting the choreography with the Spine and MSP system is the causality related to Liveness. Berthaut, Coyle, Limerick and Moore (2015) state, 'issues with visual information performance with DMIs adversely affect the perception of liveness. More specifically, a lack of visual information may impair the audience's ability to make inferences about the performer's intentions, actions and musical outcomes, and thus degrade their expectations' (2015, p. 2). To elaborate further on Berthaut et al., the issues concern both visual and sonic performance. People experience performances by looking and listening, and more often then not, the visual element takes prevalence over the experience; at least in live performance settings.

To adjust the physicalisation to sound causality in performance and composition, Hattwick and I 'combed' through each sequenced marker and adjusted both the parameters and processing, as well as the choreography and handling of the DMI, based on what I heard and felt on a kinaesthetic level. Sometimes kinaesthetic sensations are

hard to describe or in some cases almost intangible, which then causes problems in communication of intention or artistic focus. Conceptual descriptors, such as striking, grinding, tearing air, floating, and glassy were used to help further mould the sonic and visual environment. Using this approach may seem less technically driven, but it offers an entry point for success in constructing and reading the performances' sonic, visual and choreographic architecture and scope. Examples of adjustments included small movements from gesture sequence eight or full body extensions in sequence four. In regard to the extensions, Hattwick and I concluded that if they are not activating a large part of the spinal corpus through Flexion, the mapping's sonic result remains rather subtle.[68]

Heightening the visuality of the movement or expanding the actual mapping parameter, such as shifting it from a range of 0 - 1 to 0 - 10, affords a stronger impact on the sonic result of the physicalisation. Though, with such extremities, caution should be taken so to not 'over-blow' the processing currently set, as well as the choreography being performed for the sake of software stability and artistic integrity. This period of adjustment helped to sort out the visual and sonic relationships, which in the end strengthened the piece and ultimately made for a strong artistic work that is based on a hybrid between art and science. Overall, *Almost Human* represents a form of humility in expression that has enabled my practice to expand beyond notes on a page, and has given birth to new ways of experiencing art, whether acoustic or with digital prosthetics.

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[68] A compositional decision was made to veer away from aggressive sonic results every time I moved with the instrument. If this were the case, the piece would musically stagnate.

5.5 Summary of Part Two

The second part of this thesis explored the main components involved in creating a new experimental work which draws on my own performance practice as a cellist, 'mover,' and innovator. The analysis and critique of this practice has steered me towards finding new expressive avenues in the form of digital-age performance to express that which caused such frustrations in the past. The concise background given on the birth of digital musical instruments, and how that has fuelled current creations in the way of championing physicalised sound brought the research to the discovery of the Spine.

Although the Spine is a conceptual object, it is not a sound, neither is it a work, but a generator to help expand musical and artistic possibilities. The inclusion of the Spine in the work assisted in refocusing not only my relationship to movement and sound for performance, but also aesthetically, it serves as an artistic communicative tool that shows a different way in which both performers and audiences can experience music and dance. This experimental venture adds to a growing canon that allows for gestural sound to become tangible to an audience through an enmeshed 3-D representation. The audience reception following subsequent performances were both positive and informative. A common discussion thread following those performances revolved around the connection between physical action and sonic result. As was previously mentioned in the section on liveness and causality, *Almost Human* was constructed to represent a 'play on' the transformation of a cellist's performance and the balance between what is heard and seen should be clearly represented in a performance presentation. Within that transformation lies information regarding affordant and physical gestures, as well as performative movement that eventually flows into a personalised performance.

Following *Almost Human's* premiere, more adjustments were made to the mapping

parameters between the choreographed movement and the sonic result. This was done not to appease the audience's wishes, but to strengthen certain ideas in the work which were not as successful as was hoped following the first performance. By revisiting gestural sequences in the choreography and making changes in the patch treatments and their timings, my performance overtime became stronger and more fluid. Eventually, I was able to experiment even further with small gestures within the choreography that had seemed more mechanical in the first performance.

Time with the work reveals that the Spine began as a hypothetical prosthesis, and eventually evolved into a homogenised second skin that I could manipulate in real-time. The Spine hasn't replaced my cello, but has become a starting point in my practice for re-imagining new ways of expression purely through movement. It is important that this type of concept not obstruct the overall aesthetic of future research and projects, but aid in achieving critical and artistic goals.

CONCLUSION

This text explores the main concerns addressed in the instrumental, dance and interactive works submitted as part of my doctoral portfolio, more specifically in terms of unlocking the relationship between the choreographic, physical and conceptual object. At present, my body of work sits at the edges of physical, electronic, prosthetic and experimental expression. Although they are not active all at once, I borrow from their extremities to create, based on conceptual and aesthetic demands.

The multi-layered approaches in this research project favoured the physical object more, as most of the inspiration to analyse, explore and create began there. With it being the starting point, I used it as a membrane through which expression and gesture could resound on multiple planes, whether through motion capture technology or a digital prosthetic instrument that is likened to an alien cyborg. The overall goal was to find a movement system that could be adapted to an instrumental practice that would not replace its historical relevance, but heighten it in a way that could be useful in a plethora of settings. As hypothesised earlier, the use of Rudolf Laban's kinaesthetic theories in my work has not only influenced my practice as a cellist, but also my approach to collaborative and interactive creations.

We have seen in this project that both defined and less clearly defined notations, notation scores that leave more responsibility to the performer to decipher and create, opens up an exciting new world for subjective and interpersonal collaboration in relation to movement presentation. By exploring the personal physicality of performers through different analytical systems, I was able to harness a different way to tell the narrative of the composer without silencing the voice of the performer. The latter is evident in

the collaborative work with Ian Hattwick and the Spine.

It is my hope that this research will inspire other performers and composers to bend the lens that they use for creating music. The creative process can have a formal rule book, but exploration outside of that has been shown to yield exciting new possibilities. My creative process is in no way the definitive way to approach analysing music and movement, but it has provided results that I believe are useful to other researchers and practitioners interested in the musician's performance practice.

The performance practice of an artist is extremely personal, but shouldn't be seen as something which cannot be shared with the masses. Embarking on this project has expanded my understanding in regard to physicality, movement lines that are embodied and presented to audiences, as well as the controlled collaboration of movement and sound. By dissecting portions of scores and creating a tangible terminology, I have been able to finally transform conceptual sensations into tangible ideas that can be disseminated to a larger audience and at the same time free me from the constraints of one-dimensional interpretations and scored notations. Charlie Rosen said: "In any case, the most successful performance of contemporary works, as of the music of the past, are those that only give the illusion of remaining faithful to the text while they hide a genuine and deeply rooted freedom of interpretation" (1998, p. 73).

KNOWLEDGE

What knowledge has come out of this project? Can this knowledge be objective and benefit others or is it just a reflection of one musician's interpretation on performance practice?

The term performance practice is one that is both highly controversial amongst both scholars and practitioners due to it being both highly personal and intriguing for the on-looker. Prior to embarking on this research I approached music much like many other musician's — through studying a score for harmonies, creating and learning fingerings, and trying to play both in tune and in time. Since completing this project I can proudly say this has been a process many musician's should try explore. My choice of works and the methodology were designed in a way that would show the porous nature of music. Often times I've heard musicians comment that playing contemporary music is easier than playing classical. How is this possible? They both are rooted in some form of tradition that is carried down from one generation to the next, regardless of cultural or geographic location. Due to conversations such as this, my goal was to show that the language of one can feed the other, but also that physically, they share similar identities. Once you discover that, you can manoeuvre in between the two. By extracting ten gestures from works byJ. S. Bach to Lachenmann, I showed that movement and music can be altered by genre, but they share commonalities under the surface.

During the period of learning the Labanotation and Laban's theories of Choreutics and Eukinetics, I felt lost and confused. More often then not I was confused because of the complex nature of the symbols and the interchangeable nature of some of the expressive terminology. Yet, given my investigative nature, it proved to be a system that would benefit me in a multitude of ways beyond the movement and into disseminating the musical narrative.

I believe that the work presented in this project will definitely be useful for cellist's interested in learning these works, as well as exploring a deeper correlation to why they

do what they do and how they do it. Beyond this one group, I believe the results of this research will contribute to a growing corpus of musician's, ethnomusicologists, and instrument builders that are either presently researching or who may want to involve Laban's theories or motion capture as a supplemental tool to study the moving musician.

FUTURE RESEARCH

The dissertation has covered important research topics that have solidified future research that will continue to investigate and draw links between concepts and objects, whether they be acoustic, digital, or even mechanic.

To create such links, the best inspiration comes from experiencing everyday situations, as well as looking to the past. The early developments of DMIs, especially those created by Laetitia Sonamii's *Ladyglove* and Michel Waisvisz's *The Hands* have made a remarkable impression on custom interface designing and artistic output. As I write this, I have already begun work on the next project which is a hybrid of a sensor glove and EMG sensorband. The premise behind this work is likened to the findings discussed in this thesis and expand it in such a way that allows me to harness muscular expressivity that was not possible with the Spine in real-time. This new work will draw on mechanical aesthetics from the twentieth century, as well as the digital-age electronics discussed in chapter 5.

Beyond the future development of wearable technologies, I also plan to revisit the analytical work done with dancers and motion capture. One interesting find was the entrainment that occurred both in group settings with the musicians and dancers, and segmented limbs, such as the syncing movement of the head and hands or head and

knee in both the Bach *Sarabande* and Hamel's *Grey Neon Life*. This phenomenon leads me to investigate if there is a triggering force embedded in the movement of the musician, the rhythm or the score. To expand further on this, I will also look at group performances that are also outside of western art music.

There are other important future directions that I would like to explore that include collaborations and creations between performers and composers/creators, as well as interpretations. An interesting direction for exploration could be the performative and durational aspects of fluxus artist Jim McWilliams' *Ice Music for London*, which was premiered by cellist Charlotte Moorman. Ultimately, I believe that an imaginative and exploratory nature is needed to create any good piece of art, and our knowledge about musical potential and process should continue to be disseminated if only to help further the richness of the artistic practice.

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SUBMITTED WORKS

On USB flash drive

Video:

Almost Human full performance (AHV)
Almost Human rehearsal without electronics.mov (AHDance reh)
Bodied Chambers-Electronics Spring Festival 2014.mov (BCV.mov)
Des ailleurs quartet.m4v (The Quartet- Woods and SINE QUA NON)
Elinor Frey Bach performances (Bachconstr.mp4/ Bachexp.mp4)
Spine Gesture Videos
Grey Neon Life live performance (GreyNeonLife.MOV)
MoCap Session videos
Spine Test 1- Speechspine1.mov
Spine Test 2-Speechspine2.mov
The Funerals- P.A.R.T.S/Ictus.mov

Electronics:
Almost Human electronics (AH electro patches)

Scores:

PNOM for solo cello (2005)- Claudio Gabriele

Grey Neon Life for solo cello (2012)-Edward Hamel

Almost Human for cello and electronics (2014)-Ian Hattwick

Sketches:

Ten Gesture Sketches of Bach, Gabriele and Hamel

Motion Capture Qualitative and Quantitative Plots:

Bach and Hamel MoCap plots

Lachenmann MoCap plots

External

PNOM- Claudio Gabriele (PNOM)
Claudio Gabriele PNOM Seth Woods Solo violoncello (12, Nov 2012). PNOM [Video file].
Retrieved from https://www.youtube.com/watch?v=77BQ3pFnWe0

APPENDIX

Scores

Freehand Sketches

Vorwort

Die Notation dieses Stücks zeigt – mit Ausnahme der Stellen, wo die übliche Ton-höhen-Notation angedeutet ist – nicht an, was klingen soll, sondern, was der Spieler tun soll; das heißt: an welcher Stelle des Instruments der Bogen (= rechte Hand: Notenhälse nach oben) und wo die linke Hand (Hälse nach unten) agieren soll. Zur Orientierung diene jeweils die Zeichnung am linken Rand bzw. weitere Anweisung im Notentext selbst. Aus der Zeichnung ist zu ersehen, daß der obere Rand dem unteren Corpus-Ende, der untere Rand dem oberen Corpus-Ende entspricht.

Ein Teilstrich entspricht einem Viertelwert, wenn nicht ausdrücklich anders angegeben.

Dieses Stück sollte möglichst auswendig gespielt werden, auf jeden Fall aber so, daß a) nicht geblättert werden muß, b) die Noten nicht die Sicht auf Instrument und Bogen verdecken. Das Cello kann ad lib. elektrisch verstärkt werden.

Preface

Except for places where pitches are notated in the traditional manner, the notation of this piece does not indicate the sounds, but the player's actions, i. e. at what place on the instrument the right hand (bowing: note-stems point up) and left hand (stems point downwards) should operate. The drawings in the left margin and other indications in the musical text serve as a guide. In the drawings, the upper edge corresponds to the bottom of the body of the instrument; the lower edge of the drawing corresponds to the top of the body.

A division line represents a quarter-note value if not expressly indicated otherwise.

If possible, this piece should be played by heart, or at least in such a way that (a) the pages do not have to be turned, and (b) the score does not block the view of the cello and bow. The cello may be electrically amplified ad lib.

HG 865

127

4'.
5'.30
1 X

8'.3 D
2 x

Für Werner Taube

PRESSION

für einen Cellisten / for one Cellist

Helmut Lachenmann, 1969

Scordatura:

IV III II I

♩ ca. 66

gliding / push

Hold

[Bogen wird zumeist in der geschlossenen Faust gehalten]

Steg

I. Saite
pp
arco stop

Griff=brett

I. Saite
3

face/unique?

sim. + II. Saite

Hälse aufwärts = rechte Hand
Hälse abwärts = linke Hand

mit Fingerkuppe locker – quasi flageolett –
auf der Saite hin und her fahren.

Difficulty to distinguish major differences

contraction

(Steg)

Bogen unbewegt stehen lassen

sul IV

V (tonlos)
p

Bogen stehen lassen

distinto poss.

to speak

f

fff

sim. sempre

f

3

II mit Daumennagel gerieben
f gilt nur für Daumen ⟨ : cresc. evtl. durch Beschleunigung.

staccato short

contraction

(Steg)

meno

3

sul IV (tonlos)
p

f + III. Saite

more fast

p
3

rit.

pp

Space used?

shoulder throws in dance

Does it emerge visually? Patterns, gestures, identities or is it an undercurrent?

HG 865

* time damp

* sense of face & pressure not really given
  • Head / Bow speed – continuously
    recognise identity → emerges patterns (linear, travel, ...)

* embody (counterpoint –
  kinds of alignment in time
  (Trisha Brown)

128

J. S. Bach G Major *Sarabande* with annotated Labanotation symbols.
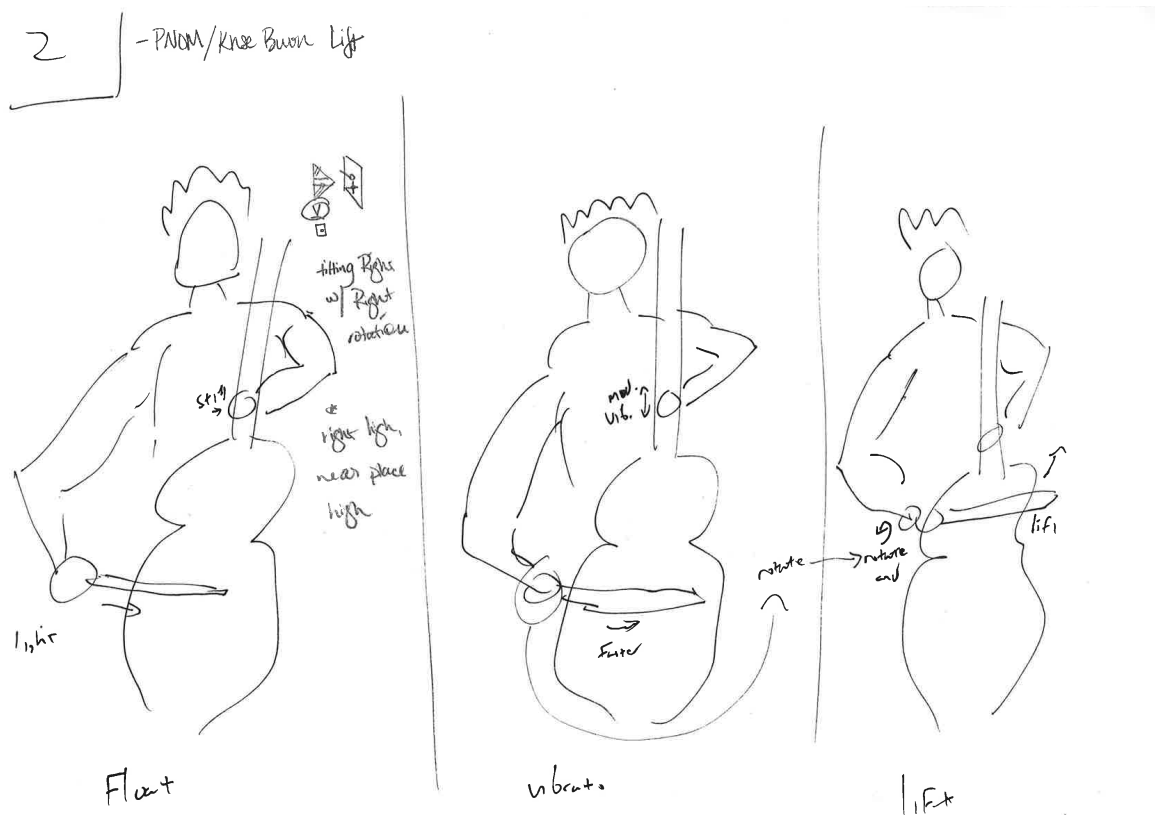
Gesture 2 from Ten Gestures: Freehand sketch of movement sequence from Gabriele PNOM along with text description and Labanotation to illustrate the Lift gesture descriptor.

Gesture 3 from 10 Gestures: Freehand sketch of J. S. Bach G Major *Sarabande* showing stationary arm position as well as adapted Labanotation to show the movement the body makes to create the sixteenths in the second measure.