

Interacting with the Piano

Absorbing technology into piano technique and collaborative composition: the creation of ‘performance environments’, pieces and a piano

by

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Abstract

This thesis explores the expansion of the piano performance environment, using technology to augment the sound, the playing area of the piano and its surroundings, and/or the performer's own body in controlling electronic elements of the music. In particular I examine the extension of piano technique and how this is affected by adding technology. I also discuss collaborative compositional processes in creating co-authored musical works and have given a critical appraisal of the different technological systems used in all of these pieces. I have also introduced ideas about developing the structure of the piano to better suit contemporary techniques and the addition of technological elements in piano playing. These ideas are represented by my own 'Inside-out Piano', illustrated within the thesis.

Throughout this work many new pieces for piano and live electronics have been generated and I hope these may also be useful as a resource for other pianists exploring their own interactions with the piano.

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List of Publications

All the publications are available in Brunel University library for reference.

Publication 1: Alexander's Annexe - Push Door To Exit

Performance

Alexander's Annexe. (2005, August 14). *Push Door to Exit* by Alexander's Annexe. *Ravello Festival*. Villa Rufolo, Ravello, Italy.

Recording

Alexander's Annexe. (2006, November). *Push Door To Exit*. [WARPRecords/WARP152] London. Commercially available at <http://warp.net/records/releases/alexanders-annexe/push-door-to-exit>

Publication 2: Expanding the repertoire for piano and live electronics

Performances

Nicolls, S. (2007, November 19). Hyperpiano project: see 'New pieces' below. *Huddersfield Contemporary Music Festival*, St Paul's Hall, Huddersfield, UK.

Nicolls, S. (2007, November 22). Hyperpiano project: see 'New pieces' below. *Cutting Edge Series*, British Music Information Centre, the Warehouse, London, UK.

Broadcasts

Hear And Now, BBC Radio 3. (2008, March 1). Barrett: *Adrift* [Nicolls (piano) with Richard Barrett (electronics)].

Programme details:

<http://www.bbc.co.uk/radio3/hearandnow/pip/5g1i3/> [accessed 6 March, 2008].

Hear And Now, BBC Radio 3. (2009, November 28) Michael Edwards: *For Magda Cordell if she'll have it* for piano and computer [Nicolls (piano) with Michael Edwards (electronics)].

Programme details: <http://www.bbc.co.uk/programmes/b00p3lzg> [accessed 2 December, 2009].

Hear And Now, BBC Radio 3. (2008, August 9) Larry Goves: *My Name is Peter Stillman. That is not my real name.*; Jonathan Green: *Into Movements*; Michael Clarke: *Emmeshed II*.

Programme details: <http://www.bbc.co.uk/programmes/b00cwz4p> [accessed 11 August, 2008].

Recording

Barrett, R. et al (2009). *Adrift*. [psi 09.10] London.

Commercially available at <http://www.emanemdisc.com/psi09.html>

New pieces

Barrett, R., (2007) *Adrift*

Edwards, M., (2007) *For Magda Cordell, if she'll have it*

Clarke, M., (2007) *Emmeshed II*

Green, J., (2007) *Into Movement*

Goves, L., (2007) *My name is Peter Stillman. That is not my real name.*

Publication 3: Collaborations with Hugo Morales Murguia

Performances

Nicolls, S., (2010, September 6), *Valves* by Hugo Morales. *Gaudeamus Music Week*, STudio for Electro Instrumental Music (STEIM), Amsterdam, Netherlands.

Nicolls, S., (2008, November 8). *espacios encordados* by Hugo Morales.

SEOUL International Computer Music Festival, Jayu Theater, Seoul Arts Center, Seoul, Korea.

New pieces

3.1 Morales, H., (2008) *espacios encordados*

3.2 Morales, H., (2010) *Valves*

Publication 4: Recital at Huddersfield Contemporary Music Festival

Performance

Nicolls, S. (2009, November 21). See 'New pieces' below. *Huddersfield Contemporary Music Festival*, St Paul's Hall, Huddersfield, UK.

New pieces

4.1 Tremblay, P.A., (2009) *Un clou, son marteau et le béton*

4.2 Tanaka, A., (2009) *Suspensions*

Publication 5: Nicolls et al – *Machines within machines*

Performances

Nicolls, S., (2008, September 3), *Machines within machines*. HCI 2008 Conference, CUC Novas, Liverpool, UK.

Nicolls, S., (2008, November 22), *Machines within machines*. De La Warr Pavilion, Bexhill-on-Sea, UK.

[N.B. Video documentation from this performance].

Nicolls, S., (2009, January 23), *Machines within machines*. De Montfort University, Leicester, UK.

New piece

Nicolls, S., (2008), *Machines within machines*

Publication 6: Nicolls – Music for Inside-out Piano (February – May 2009)

Performances

Nicolls, S., (2009, April 25). *Machines within machines II*. Arnolfini, Bristol, UK.

[N.B. Video documentation from this performance].

Nicolls, S., (2009, May 23). *Machines within machines II*. Sage, Gateshead, UK.

Nicolls, S., (2009, May 26, 27). *Machines within machines II*. Village Underground, London, UK.

Publication 7: Sonatas, Pianos, Machines and Interludes (June 2009)

Performances

Hinde, K., Malbos, P., Neumann, A., Nicolls, S., Thorn, F., (2009, May 30). *Sonatas, Pianos, Machines and Interludes*. [performed by Kathy Hinde, Pierre Malbos, Andrea Neumann, Felix Thorn and Nicolls]. the Bluecoat, Liverpool, UK.

Hinde, K., Malbos, P., Neumann, A., Nicolls, S., Thorn, F., (2009, June 2). *Sonatas, Pianos, Machines and Interludes*. [performed by Kathy Hinde, Pierre Malbos, Andrea Neumann, Felix Thorn and Nicolls]. King's Place, London, UK.
[N.B. Video documentation from this performance].

Publication 8: Nicolls. S., (2009) Twenty-First Century Piano

Conference Paper

Nicolls. S., (2009). Twenty-First Century Piano; *New Interfaces for Musical Expression Proceedings* (Carnegie Mellon, Pittsburgh), pp. 203-207.

Publication 9: Nicolls, S. (2010) “Seeking Out the Spaces Between: Using Improvisation in Collaborative Composition and with Interactive Technology.”

Journal article

Nicolls, S., with Barrett, R., Abdallah, S., Jacobson, K., Robertson, A., Stark, A., and Bryan-Kinns, N., (2010). “Seeking Out the Spaces Between: Using Improvisation in Collaborative Composition and with Interactive Technology.” *Leonardo Music Journal*, (MIT Press, Boston). Vol. 20, pp. 47–55.

Publication 10: Michael Edwards – *I kill by proxy*

Performance

Edwards, M., Froleyks, S., and Nicolls, S., (2006, December 15). *I kill by proxy* by Michael Edwards. *Kubus*, ZKM, Karlsruhe, Germany

Recording

Edwards, M., Froleyks, S., and Nicolls, S., (2009). *I kill by proxy*/Michael Edwards. [sumtone/stcd3] Commercially available at <http://www.sumtone.com/recording.php?id=31>

Publication 11: Larry Goves – *Piano Concerto*

Performance

Nicolls, S., Andre de Ridder/London Sinfonietta, (2010, June 3). *Piano Concerto* by Larry Goves. *Shadow Works*, Queen Elizabeth Hall, Southbank Centre, London, UK.

[N.B. Video documentation from this performance].

Broadcast

Hear And Now, BBC Radio 3. (2010, Jul 10) Larry Goves: *Things that are blue, things that are white and things that are black* (World Premiere) [Nicolls (piano) with London Sinfonietta/Andre de Ridder].

Programme details: <http://www.bbc.co.uk/programmes/b00swppw> [accessed 11 July, 2010].

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Declarations

Declaration of Authorship

I, Sarah Nicolls, declare that this thesis titled, 'Interacting with the Piano' and the work presented in it is my own.

I declare that:

- (i) This thesis is not one for which a degree has been or will be conferred by any other university or institution.
- (ii) This thesis is not one for which a degree has already been conferred by this university.
- (iii) The work for the thesis is my own work and that, where material submitted by me for another degree or work undertaken by me as part of a research group has been incorporated into the thesis, the extent of the work thus incorporated has been clearly indicated.
- (iv) The composition of the thesis is my own work.

Signed:
Sarah Nicolls

Date: July 2010

1 Introduction and context

This PhD investigates the expansion of piano performance through the application of technology and by changing the structure of the piano itself. It questions what a solo pianist can be capable of and how the ‘performance environment’ of the piano can be expanded both to enable a different style of playing and to create pieces for piano and live electronics that closely stitch together these different elements.

1.1 Background

These investigations have arisen from a gradually intensifying relationship with electronic sound in my practice as a concert pianist in the years 2005 to 2010. Early experiences of performing piano and tape pieces like Nono’s *...sofferte onde serene...* (1976) or Denis Smalley’s *Piano Nets*, (1990-91) led to an appreciation of the possibilities of linking the powerful acoustic properties of the live piano with the immense potential wealth of electronically-generated sounds. Electronic sounds brought the piano into a contemporary soundscape with which I was familiar and I wanted to persevere with linking these two areas.

In *...sofferte onde serene...* Nono goes to great lengths to assure his piano is fully and literally ‘submerged’ in the tape part: speakers facing upwards under the instrument, a close stereo pair of speakers, the pre-recorded piano part overlapping with that of the live performer both compositionally and sonically, and an innovative style of writing for the live performer, so as to assume an almost electronic role: discrete notes played as individual sound events, at dynamics not necessarily organically shaped, starting and stopping clearly in an almost machine-like, layering way. Perhaps of most interest is how the composer does not write the tape part into the score, but instead offers eight cue points and expects the performer to align with the tape simply by being in time. It was this question of how the two separate parts related to each other in live performance that really piqued my curiosity: instead of having the tape part fixed and the performer able to be spontaneous, I wondered how many more interpretations could be found if both parts were able to change their temporal (and eventually other) characteristics in the performance.

My earliest experience of interactive, performer-controlled live electronics was playing a piece by Jonathan Green called *Piece for piano and lamp*, which I performed at Birmingham Conservatoire in 2006 (Nicolls S., *Piece for Piano and Lamp* by Jonathan Green, 2006). This used light sensors inside the piano and a web cam to capture gestures at the keyboard (see Figure 1 in Publication Seven). Using a lamp clipped to the instrument, the pianist first interacts with the webcam by gesturing towards and away from, into and out of its field of vision, activating the web cam to trigger pre-recorded samples. Later, the lamp is picked up by the pianist and used to light up the inside of the piano to activate two light sensors placed inside, which again trigger pre-recorded sound files.

This theatrical treatment of the instrument, which acknowledges and explores the inside of the piano so imaginatively, gives the instrumental performer the chance for a similar relationship with the computer sounds as with their instrument – tactile, gestural, physically immediate and responsive. The relationships between light, gesture, sound and the real-time responsiveness of the system are dramatically communicative.

Playing this piece alerted me to the theatrical possibilities of using space in particular as an interface. Perhaps like the Viennese Actionists' recognition that both time and space could become additional elements in visual art¹, in this piece the space around the instrument became part of the 'performable' area. Working closely with Jonathan and also seeing that he had built the small bits of technology himself, I was opened up to this idea of the 'performance environment' being quite easy to expand, and was curious to see how other composers would create different solutions to this idea.

1.2 A note on 'liveness'

Simon Emmerson's working definition of 'liveness' (Emmerson S. , 2007, p. 90) includes human performers acting mechanically to produce sound and those who perform 'through electronically mediated interfaces under their immediate control'. Like performers and composers before me, I began to contemplate how to attempt to be both of these people: to be able to manipulate a tape part in real-time and thus to be able to play with the interpretation in the same way one does a solo piece. Going beyond this, why not then also attempt to manipulate, in the real time of the performance, the actual quality of the 'tape' itself, for example by adding processing?

The potential advantages of this are considered in this thesis primarily from the perspectives of performer and audience. They include creating real-time connectivity between the live interpreter and the progress of the music (allowing the performer to create the most convincing and fluid performance they can) and, for the audience, creating meaningful physical and visual relationships that better communicate the myriad electronically-produced sounds that may occur in any one piece. This vision, which Emmerson describes as 'Prospero-like' (Emmerson S. , 2007, p. 93), works on the traditional instrument paradigm, proved over hundreds of years to be a powerful communicative mechanism. It was with these thoughts that I began to look at developing the pianist's 'performance environment'.

1.3 Research Questions

After consideration of the relevant contexts, the main questions that have driven the research for this thesis are:

1. How can the performance environment of the piano be developed to include technological additions that aid the live control of electronic sonic elements?
2. How can piano technique absorb extra technological elements and be enhanced by these new demands?
3. How might the perceptive experience be improved for the audience, to create more meaningful and communicative links between what is seen and what is heard?
4. Structurally, how can the whole instrument be made available to the performer, without hindering acoustical or mechanical properties and enabling greater engagement with relevant technologies?

¹ 'Material action is painting that has spread beyond the picture surface. The human body, a laid table or a room becomes the picture surface. Time is added to the dimensions of the body and space' from Muhl, O., *Material Action Manifesto*, 1964 (Selz, 1996)

2 Publications

2a Collaboratively-created compositions

2.1 Publication 1: Alexander's Annexe - *Push Door To Exit* (November 2006)

My experiences of piano and live electronics began with a group I formed with David Sheppard – a sound designer and composer and London Sinfonietta Principal as one half of Sound Intermedia (SoundIntermedia) – and Mira Calix, an electronic composer released on the WARP Records label (WARPreCORDS). After meeting through the London Sinfonietta and WARP Records collaboration *Warp Works and 20th Century Masters show* (London Sinfonietta, 2004), we decided to form a trio, to continue the exploration that the event itself had started: to seek out a musical language, created from our distinct musical areas and the overlapping common factors. It was our intention to meld avant-garde language with elements of electronica and our first commission was to create an outdoor event in the Ravello Festival (Annexe, Ravello Festival, 2005). We created a thirty minute piece which began with audience interactions using microphones placed next to enticing, playful objects around the garden and paired with speakers hidden close by; these interactions generated sounds that we captured and used as extra elements in the live performance of the piece.

2.1.1 Process

Supported by Aldeburgh Residencies (AldeburghMusic, 2005), we set about investigating the sonic palette we could inhabit, how it could be performed and how we might compose collaboratively. We had no sense of hierarchy – we would all be the composers and performers. The palette, we decided, should be entirely derived from the piano and we set about making a large library of sounds, many from inside the piano using a variety of objects including pebbles especially (we knew the pathways in the garden were pebbled and we already had the idea of using boundary microphones to capture the audience's crunching feet as they arrived). These sounds would form the backbone of the electronic part Mira would play during the performance.

To begin to compose the piece we had to find a common language with which to talk about music. This was difficult as our backgrounds, specialisms and familiar processes were all rooted in different fields: Mira could not read music and was not familiar with vocabulary like 'tonic' and I was not familiar with computer programming, so did not know how to describe different effects or sounds or even perhaps know what was possible.

Another challenge we faced was the different ways we each generated sound. Combining instrument and computer created tensions: at an instrument sounds can be created immediately, whereas a computer is dependent on either receiving sound to process or selecting an appropriate pre-synthesised sound. Where instrumental collaboration may progress straightforwardly with harmonies, phrases and textures heard by everyone present and discussed, accepted or rejected and developed with the same reference points, working with computers seemed to have to happen at one

remove: there was what felt to me like a negative cycle where we couldn't proceed without sounds but also couldn't create the sounds without knowing what the piece would be. (A basic palette could be assembled but even then, manipulation, processing and re-writing all took time). The time-lapse between exchange and generation of ideas was difficult for me as an instrumentalist: I needed to hear ideas to understand them but the two computer musicians needed to consider what we were going to compose *before* they could create any sounds.

We decided therefore to focus on what we felt the character of the piece we wanted to write might be and accordingly drew a journey we felt made sense to us. We used shapes (see Figure 1), emotive words and textural descriptions to bring into a common place what our imaginations fed us. Going back into the studio we then worked from the opening, using the pre-recorded sounds for Mira's palette, and began to improvise live piano on this, focussing on motifs and textures that reacted well.

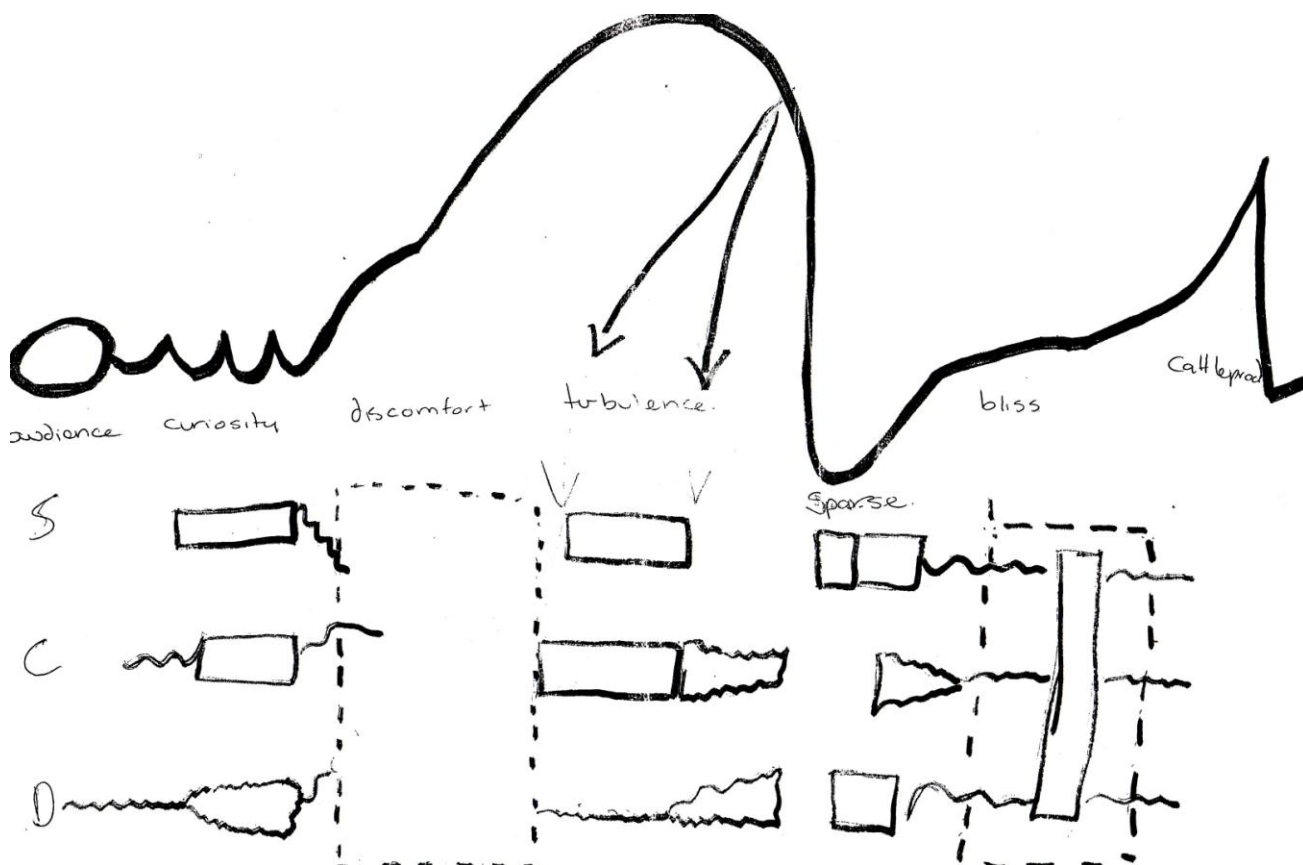


Figure 1. Our first score, with our three parts (S, C and D) sketched out underneath the structural overview

We worked collaboratively to create the piano writing (me playing something, then the others commenting or playing the piano themselves) that we felt worked for each section and then returned to our library of sounds to establish the basis of the next section. Working in this way we established musical ideas and then had to discuss what the live electronic (ie reactive/live processed) part would be: what it would add. Talking again in quite emotive terms, we generated ideas about how the computer might react to some of the motifs (for example, throwing the sound into a low granulation, then spinning the result around the room).

Whilst David programmed, Mira and I improvised at the piano and interestingly, these rather informal duo sessions really helped us to find common ground. Although our experiences were entirely different, using quite opposing approaches to the keyboard (her: minimal and melodic; me: quite texture-based, often very virtuosic or busy, usually atonal) we gained access to each other's sonic landscapes. A key feature that we unearthed as a group was the idea of micro development. As a resolute avant-gardist, I was ideologically opposed to repetition, minimalism, sweet tonality and so on but gradually discovering the worth of sticking with something and changing it incrementally I became much more sympathetic to harmonies at least based on a recognisable tonality. Working with electronic processing, we would often discover the qualities by using the same piano sound, gradually altering the processing parameters; this tuned me in to *remaining* with the same musical idea for longer, as this was more effective in this context to hear the changes in the electronics than simply jumping from one musical extreme to another.

Combining the musical material with processing generated extensive improvisations and discussion. Quite early on, we began to consider how the piano and David's computer might be linked in live performance – how the piano's spontaneity might control changes in the programming, to create better syncing of the two. We bought a PianoBar (MoogMusic, 2003), which is a rail that holds a row of optical sensors at the back of the keyboard, facing down, so the velocity of each key can be read and translated to MIDI. With this we programmed very simple control functions, for example the ability to access different sounds, or to control which processed response would be used. Although basic operations, these gave me an early insight into linking live piano performance and electronic responses.

2.1.2 Output

The resultant composition was *Push Door To Exit* (Annexe, Push Door To Exit, 2006). It is a twenty-seven minute part-composed, part-improvised piece with a fixed soundtrack mixed live by Mira (made entirely from the recorded piano sounds). The structure adhered to the shape that we had drawn, with the timeline dictated by how material developed and expanded. Playing over this 'soundtrack', the sections and structure of the piece remain the same each time, as do the basic piano motifs. What changes from performance to performance is how I develop the material within each section, for example how a motif is gradually shifted down the keyboard or how textures are added to or layered (and responding to these changes, how David's processing then also creates different sonic results).

2.1.3 Notation

The scores we created were all different, though we also created one score that made sense to all of us. Mixing graphic and traditional notation, the timeline and emotively named structural parts (eg TURBULENCE, BLISS) enabled us to create fixed sections on the score that we then completed with the most useful but minimal pictorial or notational elements. My own score (see Figure 2) was only one A3 side for 30 minutes, indicating how little literal notation there is. Some motifs are written out precisely and exactly, but beyond this and with these, there is much improvised development. It is, however, notated precisely enough so that I am able to play it with the same motivic and harmonic material every time.

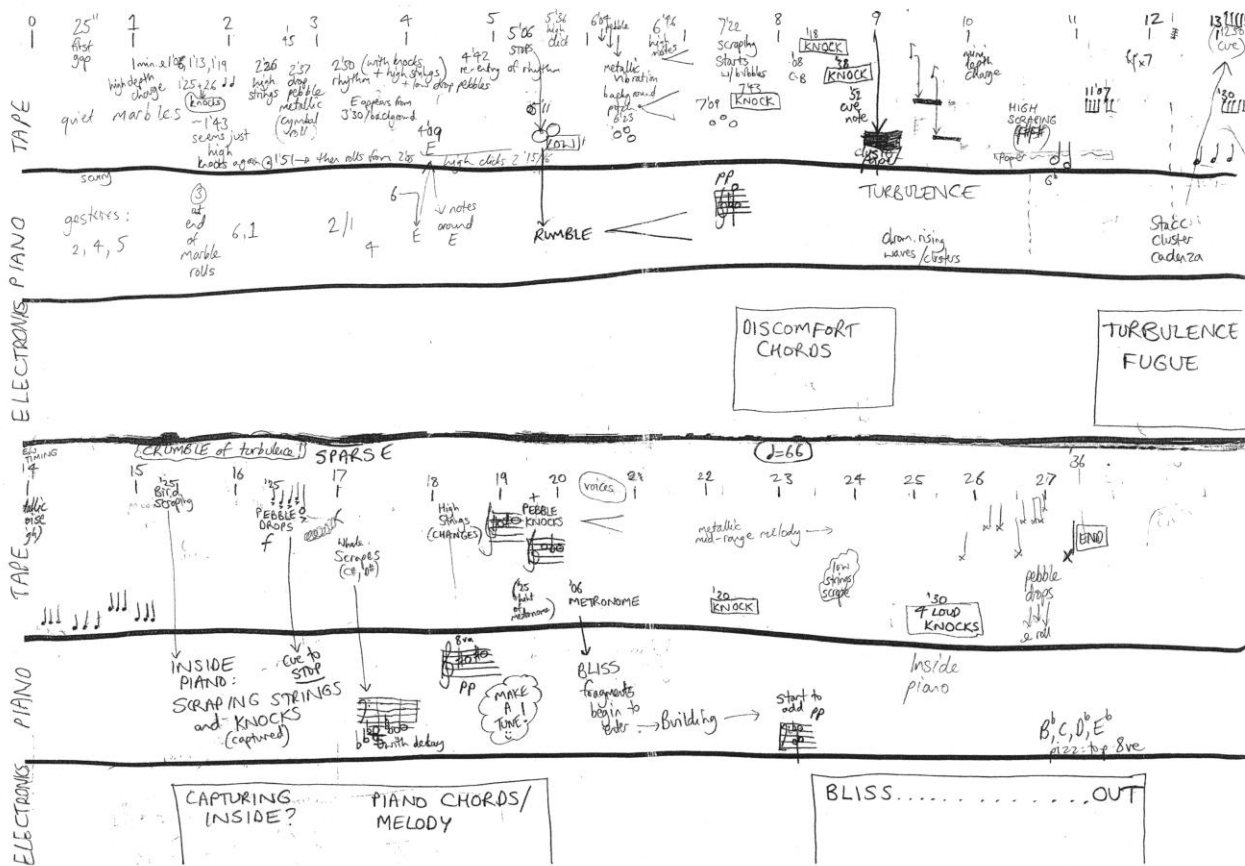


Figure 2. My own score, showing the full timeline of twenty-seven minutes and all three parts: electronics (David), piano (myself) and 'tape' (Mira)

2.1.4 Conclusions

To conclude, Alexander's Annexe began my collaborative composition journey - it introduced me to how electronics might be performed live and it gave me my first experiences of improvising in public. Although the 'interactive' element was absolutely minimal – using the PianoBar to control basic functions of changing a sound bank or instigating a change in the computer's response – it introduced me to the possibilities of controlling from the keyboard and crucially also introduced me to how live processed responses could sound – how the piano could become something altogether different: more complex, spatialised, greater in volume and so on. Learning about working with technology was very useful too: understanding how much time computer programming needed was instructive. Knowing that not all things can happen instantly has become more and more vital the more I have worked with live electronics: my work with technologists in the PianoLab (see 2.5.1) for example really benefited from me having learnt these lessons early on.

2.2 Publication 2: Expanding the repertoire for piano and live electronics (November 2007)

2.2.1 Overview

Having learnt from Alexander's Annexe the benefit of collaborative creation especially when using electronics, I decided to embark on a major project seeking to enlarge the repertoire for piano and performer-controlled live electronics. The resulting Arts and Humanities Research Council (AHRC, 2007) funded project, conducted in 2007, resulted in five² pieces being performed twice, at the Huddersfield Contemporary Music Festival 2007 and at the BMIC's Cutting Edge, London, the latter recorded by the BBC and broadcast on Radio 3's *Hear and Now* programme (HearAndNow, 2008) (HearAndNow, 2009). I worked with all project partners to create pieces across the full spectrum of possibilities from 'guided improvisation' to fully composed and from using only simple analogue electronics to using MAX/MSP and other innovative software. I wanted the pieces to highlight different elements of electro-acoustic performance: technical, compositional, aesthetic and theoretical, as well as a range of performance issues and this guided my choice of composers/collaborators, some of whom are experts in the field of electro-acoustic performance, some newer to the process.

I divided the research project into four sections to direct my understanding and engagement.

1. The first objective of my research was to become competent with a range of electronic equipment, developing methods and techniques for controlling electronics from the piano whilst performing live. There were many physical and logistical questions to be answered and increasing levels of complexity and technological involvement.
2. The next objective was to begin to define my own electro-acoustic language and in doing so, to engage with compositional and improvisational questions in practical sessions with the listed research partners. I wanted to explore particular improvisational issues such as complexity, structure, consistency, whether idiomatic results occur particularly with electronics and if so, whether strategies could or should be developed to avoid them.
3. My third objective was to investigate the gestural control of electronics: specifically to explore the use of sensors in increasing performer autonomy in electro-acoustic performance. I wanted to investigate whether I could control sonic manipulation through gesture with enough sonic complexity, without impacting on my natural approach to the keyboard.
4. I also began a consultation process investigating the possibility of eventually designing a new electro-acoustic instrument, what I referred to as the 'HYPER-piANO'. In a very moderate form, the first prototype of this was built using funding from a Brunel Research Innovation and Enterprise Fund Award (December 2007 to May 2009) - see below.

2.2.2 Richard Barrett – Adrift (2007)

Please refer to Publication Nine (2.9) for more on this piece.

Having performed Barrett's solo piano piece *Lost* (2004) previously, I invited him to create a new piece for me with live electronics. He decided to use *Lost* as a basis for this new piece and recorded me playing it. With these, Barrett created his own part, re-ordering and processing slices of the recording to perform with his keyboard system (using the LiSa system developed by the Studio of Electro-Instrumental Music, Amsterdam (STEIM)). For the resulting semi-improvised duet we therefore both had a roughly similar amount of musical material, with me using *Lost* as my base material. The next layer was formed by each of us improvising, and this lasted approximately the same amount of time

² A further improvised piece was created with Ruth Wall, harpist, but this is not discussed here. (Wall, 2007)

as the original piece, roughly doubling the original length of *Lost*. The improvised material related in language and style to the original material and was to be interspersed following the original rules of composition: a technique of insertion, where Barrett had designed phrases that constantly interrupted themselves, in varying regularity and with varying lengths of interruption.

The piece was a great success in terms of creating a fully cohesive acoustic and electronic part: the tightly woven compositional and rehearsal processes meant our parts were so intertwined that I was almost able to improvise in the language of Barrett's original composition, not something I would have expected to be able to do when starting out learning *Lost*.

In terms of giving me control of the live electronics, however, the piece was in theory a failure but this was for good reason. At the very beginning of the process Barrett decided that he wanted the piece to very much resemble a two piano piece and observing the performance video one immediately sees that this is a duet. It emerged that I wouldn't be controlling any of the electronics and instead Barrett would play all of the electronic sound while I played the piano, both notated and improvised parts. I think in part his choice was also based on how much he felt I *could* control: with Barrett as a performer, he could respond quickly to complex changes in the music in real time but also provoke my own interactions with the piece whilst it was going on. However, I also see Barrett's choice of the duet format (instead of giving me full autonomous control) as his way of leading me into the material and also retaining a level of spontaneity in his own compositional process. The artistic needs or aims therefore really led the technological requirements and set up, rather than my own seeking out of direct, interactive control.

Although I wasn't in control of any of the electronics, I did find that having created the samples myself I was tacitly connected to the electronic sounds through knowing their musical basis intimately by literally having played them. The connectedness I had with the electronics here therefore served to illustrate a different possible partnership between the instrumental and the electronic that was still as close and crucially, still as *live* (and therefore changeable by spontaneous interpretation) as any other performance.

2.2.3 Michael Edwards - For Magda Cordell, if she'll have it (2007)

'*For Magda..*' was a fully notated piano piece which I could practice entirely without the electronics part. It was very virtuosic, very fast and dynamically very varied, written in a loosely jazzy style.

Michael Edwards' outlook on performer-controlled electronics was similar to Barrett's. Edwards was also used to performing his own live electronics and therefore felt at home with controlling complex live processing techniques, not with relinquishing control of these to an instrumentalist. Edwards' performing experience with several instrumentalists impacted here: like Barrett, he was also very used to performing in the role of 'electronics performer'.

Although we did enter into the collaboration with the idea of giving me autonomous control of the electronics, however, it did become clear whilst investigating that the fine grain of control Edwards wanted would not be possible: there would simply be too much for me to do and play the piano simultaneously. We tried using pedals to trigger sound files but then had the problem that I would have limited ability to control their volume. We then discussed volume pedals but found

that there would be too much for me to process interpretatively and with different parts of my body at very great speeds (the piece is fast and furious almost throughout), and I would also not have the best aural vantage point at the piano for a very full electronics part. So, again the situation of duet seemed most appropriate and again I was forced to reflect that technological demands or aims cannot lead the artistic process: the piece Michael had in him to write for me would have been corrupted artistically if he were to relinquish the electronic sounds' control.

I surmised that I would continue to encounter a physical limitation in what I could control if I continued to only use external interfaces of pre-built objects (guitar pedals or fader boxes). The experiences of the Barrett and Edwards led me to contemplate using bio-signals, so that I might be able to control the electronics innately and in a detailed manner *whilst also* playing the piano. However, when considering this, I also reflected that the dexterity available to a computer-user in terms of the playing of the electronics might never be reciprocated in a 'hyper-instrument' set up. Thinking of a hand-worn, totally mobile external interface such as Michel Waisvisz's *The Hands* (Waisvisz, The Hands, 1984) - a pair of gloves with buttons, distance and positioning sensors including inclinometers, and bend sensors on the fingers - gives some ideas on the number of permutations possible using just one's hands to play electronics. Imagining playing *The Hands* (Waisvisz, Michel Waisvisz, 2003) *and* the piano at the same time would surely be nigh on impossible but I did go on to explore this further with Atau Tanaka (see 2.4.2).

2.2.4 Michael Clarke – *Enmeshed II* (2007)

This piece (or specifically, my part in it) was also a fully notated, straightforward piano piece that could be practised without its electronic part. The latter element was all created by live processing, through MAX/MSP, using a patch that had been the basis for Clark's previous piece for saxophone: *Enmeshed* (2005). The two pieces both focus heavily on spatialisation, moving sound around the 8-channel system in sometimes quite rapid ways, over and across the audience. The fog~ object (Clarke J. a., 2002) enabled Clarke 'to move smoothly between timbral transformations close to the original, right through to complex granular textures', and IRCAM's SPAT (IRCAM, 2011) software allowed 'textures [to] be given depth, the different layers varying their spatial position independently just as they could adjust their distance in terms of pitch, timbre, texture...it is the perception of different distances and positions for different parts of the texture that is most significant..'. The technological processes are explained in detail in Clarke's paper (Clarke, 2006).

There were two distinct discoveries made from working on Clarke's piece, the first of which during the making of the piece, where we investigated possible ways to make the piece interactively controlled. The main research we conducted was using the PianoBar and involved taking velocity readings mapped to dynamics. I would attempt to play a *ppp* note say eight times and we took the velocity readings, to see if by judging a dynamic level we could create a simple at-the-keyboard control function. We discovered that there was great inconsistency matching the perceived dynamic level and the velocity output data of the PianoBar, which was surprising since technically the two factors should be absolutely matched. We concluded that the PianoBar reading was not accurate enough for this kind of control and reverted instead to patch controls using a trigger (initially done by someone score-following in the performance, but later developed by Richard Dudas to be controlled by a trigger pedal for a performance of the piece in Korea (Clarke, 2008)).

The second reflective moment came when watching the DVD of the performance, two or three months after the event.

Probably the most poignant moment in the reflective process was when I observed myself (on the DVD) turning the page of Michael Clarke's piece. I knew that the sounds were whizzing all around the room at this point, with huge energy and varying angles and speeds and I was immediately struck by the perceptual dissociation of that moment: a total disconnect between the audience's visual and aural experiences. Here I was struck by the idea that if I retained responsibility for the sound beyond simply 'feeding' the computer, then this kind of disconnect would be easier to avoid: I would simply not be able to be so passive whilst sounds were flying around – instead I would be part of their flight. I determined to explore this circular performative feedback more and had some specific ideas about how the performance could have been performer-controlled, for example I imagined a foot controller like a flat panel rested on a ball to control spatialisation, with the panel corners mapped to the corners of the room.

2.2.5 Jonathan Green – *Into Movement* (2007)

This commission used accelerometers on each hand (other sensors such as a flex sensor on the right elbow and a compass 3D sensor, which read position relating to a calibrated point were rejected as too complex for the amount of time available). We established early on a very thorough and succinct research method to collect data: filming me playing specific notated gestures on the piano whilst wearing the sensors, with the computer screen in the background so that the sensor readings were also visible. In this way, visual and sensor information data was captured in a measurable way, to allow notational and gestural events to be compared. This method yielded information to guide Green in the process of composition, and allowed him a laboratory-type setting whereby he could ask me to perform particular movements and record visually what data they gave out. The aim here was to create total harmony between pianistic gesture, sound and resulting electronic sound so the system was kept simple: the accelerometers were controlling the pitch bend of the live sound produced at that exact moment.

The result was a system mapped to innate pianistic gestures, which were simply exaggerated to create more pitch bend. I found the system absolutely instinctive and intuitive: I knew exactly what my movements would do to the sound and could easily relate how I played the piano – i.e. both gesturally and sonically speaking – to what the processed output would be. Here we had created the full circle of performative feedback: I played the sound, the computer processed it but then I could also play the processed response. The response responded to parameters such as input volume (my piano playing) as well as the gestural shapes, so I really had two control mechanisms and a total integration of the two.

I was sure that the interactive element of this piece would be easy for the audience to understand but interestingly the audience feedback was directly divided. For some, the gestures were so innate that they found it hard to perceive how the sensors affected the sound while others said they had immediately understood it and sensed a very personal connection. In aiming to create an obvious gestural connection for the audience between what the electronics were doing and the way I was controlling we were perhaps restricted by the processing chosen: possibly the pitch bend was difficult to comprehend or too subtle to perceive. In terms of the timing of gesture with sound, in this case there would not be an immediate sudden sound but simply an increase in the vibrato-like sound. The fact that I had learnt to play 'under the radar' – keeping my hands very low and close to the keyboard – alternating with a more exaggerated style of playing, seemed for many to translate into it looking simply like I was playing the piano very gracefully whilst the sound had a disconnected undulation.

2.2.6 Larry Goves – My name is Peter Stillman. That is not my real name. (2007)

This piece consisted of seven movements and was written for piano, MIDI keyboard (controlling 88 pre-recorded samples) and distortion pedal. The keyboard was not touch sensitive and the samples remained constant throughout the piece so this was really like playing a tape part live. The conceptual framework of this piece was very rigorous, based on Paul Auster's *New York Trilogy* (Auster, 2004) which deals with confused, double identities thus the piano-keyboard relation served a poetic and technological purpose.

Having such a clear visual separation of the electronic and acoustic sound sources, by placing the keyboard on top of the piano, made this piece easily understood. It also created a performance environment for real virtuosity. Interestingly, although I had no dynamic control over the dynamics, lengths, attacks and so on of the samples, because of the way the samples were contextualised differently throughout the piece it seemed as if I was playing two pianos and I felt very much like I was playing the keyboard with as much care, attention and pianism as the piano, even though subtle changes in approach really made no difference. It is fascinating that a system that had a really quite fixed interactive element enabled me to feel very free.

The notation of this piece (see Figure 3) was also interesting. Larry presented three staves representing the keyboard, the piano and the sonification of the keyboard (i.e. the samples). I had input early on as to how this might appear and we changed font sizes and layouts to attempt to make it as clear as possible. See 2.11 for more on this.

Figure 3. Goves: *My name is Peter Stillman. That is not my real name.* (2007); opening of the first movement, *Popular Mysteries*

2.2.7 Overall project conclusions

Much was achieved during this research programme, with tangible results. We produced six new pieces for piano and live electronics that were all performed and notated to some degree. Referring specifically to the original aims, I gained expertise in controlling electronic equipment from the keyboard, discovering both logistical answers to problems and aesthetic frameworks for these problems. The compositional considerations of working with electronics were a rich source of collaborative research: I had several in-depth discussions with the composers, resulting in challenging performance situations and notational developments. The Barrett led to what I would have thought impossible: improvising in a four-layer piece using the most complex score I have ever learnt as a basis for the material.

Research into gestural control resulted in a new piece for sensors worn on the arms controlling the live piano sound. As a development process, for composer/sensor builder Jonathan Green and myself, this served as a first hand introduction into how the innate physical expressivity of pianism could be harnessed and paved the way for my next sensor project with Atau Tanaka. Consultations with piano builders and other instrumental or electronic developers during the project also paved the way for further developments.

2.2.8 Issues to be addressed

The issues that I really felt needed addressing after this project were:

- 1) the sense that simply playing ‘into’ a Max patch creates a one-way system;
- 2) the performative and visual connections: how to avoid dislocated sensory experiences (or embrace them but only with the intention of these as the result, rather than having dislocation by accident);
- 3) how to work with composers to better achieve the stated aim of creating interactive pieces that:
 - a. would better use the physicality of the pianist and
 - b. could be passed on and re-created by other pianists;
- 4) with regard to interactive performance systems:
 - a. how to be sure that if an interactive system was desired to be communicative it would be;
 - b. asking whether the relationship should always be one that the audience could perceive; whether gestures *needed* to be understood by the audience to be controlling certain parameters or whether that didn’t matter.

2.2.9 The collaborative compositional process: Soundwaves Festival (July 2008)

To tackle Issue 3 listed above, I sensed that more work was needed on how to develop collaborative processes with composers and set about commissioning composer Christopher Fox to create two noise interventions (Fox, 2008). I had wanted to access the process of how composers compose for performers and to be part of this process, rather than simply receiving a score. I asked Fox to act like a theatre director – to come to live rehearsals, to guide and listen to improvisations, to comment on these and mould them and then to create instructions for the performer (me) to recreate the moment in improvisation that had worked. The aim was for the composer not to have to notate everything, but instead to design the sound world and design the shape of the piece and communicate this in a much more directorial way – broad brush strokes rather than specifics to start and then gradually refining it down to whatever level was needed.

Spoken instructions and demonstrations really replaced notation in this experiment, providing some useful insights. I

found that it wasn't too difficult to focus in on the right kind of texture desired by Fox and then beyond this, shaping the basic format, discussion in rehearsal bypassed potential misunderstandings by creating a sort of immediate feedback loop as well as being free to describe the musical textures and shapes in any vocabulary not normally available in a notated, even skeletal, score.

The resulting collaboratively generated piece seemed to point towards this prototype process being a useful starting point for further investigations into interactivity. By challenging the accepted notational norms of how music can be conveyed to a performer and asking whether a collaboration could side-step hours of writing complex notation and reading complex notation it seemed that we had discovered a useful place - quite apart from notation - where verbal instruction, demonstration, immediate feedback and almost directorial guidance lent greater integration to the creative process. From this point on I was inspired to try to work in this way more thoroughly with composers on future live electronics projects, to begin to answer the other issues listed above.

2.3 Publication 3: Collaborations with Hugo Morales Murguia – *espacios encordados* (November 2008) and *Valves* (September 2010)

The piece created for me by Hugo Morales Murguia was an exploration into using the resonance of the piano with very small speakers to create feedback. The project led to useful research on several levels: notational, gestural and in creating another new 'performance environment'.

2.3.1 *espacios encordados* (November 2008)

Building directly on the work described above for Chris Fox's noise interventions, Hugo and I had several sessions where I would perform improvisations based on information from and directed by Hugo. Hugo wanted to create two movements – one, a tightly-energetic percussive explosion of virtuosity on the highest keys, with the strings dampened by *blutac* and the other, a slowly developing exploration of the resonances of the inside of the piano, with the sostenuto pedal held down throughout. One of the areas of discussion was about how best to present the material in notated form, to achieve what Hugo wanted without over-complicating (and therefore possibly hindering) the intended maniacal opening. We discovered that shapes were not enough on their own and instead, more accurate readings of dots were needed, with a relativity shown. The first movement also needed some control in changes of the frequency response of the patch and we needed to ascertain what the best interface would be for this. We both wanted to keep the piece small scale and Hugo knew I had an icube board, so he built simple button sensors for this, which we then tried in several different areas around the keyboard. We found that right next to the top key was the easiest possible place for me to reach quickly; we also realised during rehearsals that it was important that reaching for the button should be a discrete movement in performance, as it was a gradual shift in frequency response that really needed to be received aurally rather than visually. The first movement built towards a climax, with the highest frequencies of the percussive sounds accentuated, and then stopped.

The second movement used five speakers placed inside the piano. Hugo wanted me to play with the feedback of these speakers so asked me to wear microphones. I had already done some work with small microphones for Alexander's

Annexe so I suggested we use tiny condenser microphones attached to the insides of my wrists. Hugo spent a long time experimenting with the set up and then taught me in rehearsals the techniques he was using to agitate the speakers.

What arose was a kind of dance – using one hand to pluck the string to give some input to the speaker, then using the other hand to point the microphone directly at the speaker to create the feedback. The resonances behaved as feedback does: independent crescendi coming from each speaker as I held my wrist to it. Gesturally, this was a fascinating process as it was opposite from the previous interactive work I had done – here I was not deciding when or how the sound would change but instead responding to when and how it did change: I was following the sound rather than commanding it (as feedback is such an organic, analogue process, depending on so many variant factors such as piano, room and so on).

The notation for the second movement was much looser and here I found that I needed a lot of coaching to get the right shape of the piece. As a result we discovered that the score would need developing further for this movement, increasing the detail of directions to really make it transferable without the need for coaching. There is further detail on how we developed the information that would be needed by another performer in the score in Chapter 3.

This piece resulted in another new electronics environment, exploring the resonant qualities of the piano. It pointed again to the theatrical possibilities of working inside the instrument and taught me how to create resonant textures through layered feedback. It helped to clarify the collaborative process between composer and performer and further investigated notation and how a score might be created collaboratively.

2.3.2 Valves (September 2010)

This project was a commission from Stichting Conlon (Conlon, 2010) to create a new piece for Yamaha Disklavier (Morales, 2010), specifically to exploit experimentally the potential possibilities of the instrument. Morales explored the automated nature of the instrument with the piece starting with me offstage and the piano playing itself with the action in silent mode. I then had to interact with the instrument in a variety of ways, sometimes only pedalling while it played itself, at other points controlling the volume of it using the left pedal as a sensor (using the MIDI information to control Hugo's software). I also had to lower the keyboard lid and play pressure sensors that Hugo had stuck to the keyboard lid, the pressure controlling the rapidity of repeated notes that the piano played itself. Regarding this control, we had to completely change the repeated notes part in section 2. At first, Hugo was using the left pedal to control the speed of the repeated notes and the velocity of the hand to control the volume. However, in rehearsal we discovered this was unintuitive and after some exploration mapped the pedal to four stages of volume intensity instead. Although an inversion of the normal use of the left pedal (i.e. now when the pedal was more depressed the sound got louder) this was an easier transition to make than into considering the left foot as a speed control.

The most innovative part of *Valves* in my opinion is the use of the pressure sensors on the keyboard lid. Here, the pressure placed on the sensors controls the volume of the repeated notes played by the Disklavier under the closed lid. What is excellent about this as a performance system is that it lets the machine do the potentially exhausting mechanical work, whilst the human performer inputs all of the sensitive dynamic shaping required of the phrases. The system is completely intuitive, allowing the performer to concentrate solely on the intensity desired and enabling very detailed voicing of the repeated lines.

2.4 Publication 4: Recital at Huddersfield Contemporary Music Festival (November 2009)

Refer to Publication Nine (2.9) for more on these pieces.

2.4.1 Pierre Alexandre Tremblay – *Un clou, son marteau et le béton* (2009)

This publication represents a coherent integration of interactivity, notation and improvisation, which I believe could easily be passed to another performer to play without much extra instruction. The method we used to achieve this is detailed in 2.9. In particular I found the responsiveness of the ‘performance environment’ subtly organic and life-like. It really was as if I was improvising with another human in places. I think the single biggest factor contributing to this success was that it used a mixture of sources for data. There were microphones listening out for when I changed a texture, played a particular succession of pitches or played at a certain volume; the PianoBar picked up MIDI information such as specific pitches – and Tremblay often divided the keyboard, so different triggers could be given within one piano texture; there were many different kinds of trigger, so at one point the computer might be listening for two seconds of silence in my left hand and at another, be waiting for the fourteenth note of a sequence. Although at first, these multiple layers of information seemed daunting to learn, in fact I ended up being able to simplify the whole piece onto one sheet (see appendix).

2.4.2 Atau Tanaka – *Suspensions* (2009)

For Atau Tanaka’s piece I used work-in-progress as a method, also working with experts such as sports scientists and a physiotherapist to learn about performing with the sensors. I attended sports science lectures and a practical session at Liverpool John Moores University with Jos Vanrenterghem and these sessions were very instructive in discovering more about the muscle’s responses or characteristics, gaining detailed information into how the messages were picked up by the sensors and how the data therefore related to the sensor’s alignment with the muscle. It was through these sessions that I discovered that the *icube* (InfusionSystems, 2009) sensors are really too large for my arms, as they cover a larger muscle area than is really ‘available’ to the sensor on the surface of my own arm (I have very thin arms!). Resolving this properly would probably entail finding smaller EMG sensors, possibly using individual tabs, such as can be seen in figure 1 of Saponas et al, 2008 (Saponas T. Scott, 2008).

Seeing a physiotherapist was incredibly useful, for looking at the anatomy of the arms and discussing how using these sensors as controllers might affect both my base physical wellness and the fine-grained tuning of my piano playing. Essentially the advice was not to worry: it seemed that after nearly thirty years of piano playing, my body would know so innately the movement required for piano playing that it simply would not be able to unlearn them or be displaced by another technique. However, I was also given an exercise to strengthen the muscles that were being read by the sensors, so that if I needed to create a large signal (for example, a threshold reading to trigger a particular event), I could do this without unnecessarily damaging myself. With the forearm resting on a stool, I had to stretch out the hand and, holding an object to maintain the stretch, raise just the hand up and down; this isolated and strengthened the particular forearm muscles needed to give signals.

I gave a showing to a theatre audience (Nicolls, Sunday Lunch Club, 18 October 2009, 2009) that gave me many insights into how different audiences in particular perceive gestures and gestural meaning: when stepping on the MIDI pedal to

trigger a patch change for example, one observer noted it was ‘as if you are stepping into a different world’. Their comprehension of the body in motion was also invaluable to me: I had thought it would be obvious my *arms* were controlling the sounds, as they usually do, but because this showing was without a piano I simply stood up to perform and in fact some people had been wondering what effect my *legs* were having on the sound while also finding them rather static and under-used. I also performed to a public and medical specialist audience (Tanaka, 2009) who, through written feedback questionnaires, gave me further insights into tension, particularly the emotional connection that the audience had felt with the performance when witnessing quite extreme tension in me.

After realising the complexity of the layering of musical and theatrical gestures, I began to really consider the whole of the performance again: the interplay of all of the gestures now present. Having delved deeply into the physicality of playing and performing, and having discovered this very intimate sensation of creating a duet within my own arms (between the control of the *external* object of the piano and the *internal* readings of the muscles), I was keen to marry more closely the sounds that was controlled by each of these outputs. I therefore felt very strongly that it would be useful to look into only working with one single sound source to fully explore this ‘double-playing’. Reflecting on the separate sonic languages of piano and electronics in the format of the Tanaka (ie no live processing, but instead acoustic piano plus processed samples) I wanted to explore a situation where the sounds came from the piano only and were then processed live.

2.4.3 Continuation work into sensor systems: Gesture recognition system with Nicholas Gillian

Following on from the piece created with Atau Tanaka, my next exploration with arm-worn sensors was undertaken with Nicholas Gillian (Gillian) at the Sonic Arts Research Centre, Belfast, using a Polhemus tracking device, with a magnet on each hand. We programmed areas above the piano keyboard to be trigger points and incremental controllers (ie by entering the ‘zone’ whilst having the hand tilted left or right, in degrees). The only sound source we used was the live piano as I wanted to find if creating a total sonic cohesion between the ‘resultant’ and ‘active’ gestures would make better sense of the piano-sensor dynamic. I wanted to discover if using these things with a single, unified sound source would mean the gestures could work more together rather than in opposition.

I also wanted to return to my initial ‘ballet in the arms’ moment (see Publication Nine): to find again the feeling of breathing or bowing the piano, the exact opposite of what a piano does: attack then decay. This had given me a very definite reason for using the technology and felt meaningful: quite unlike trying to make one’s arm a switch, for example (i.e. simply giving threshold readings).

The sessions that I undertook with Gillian will be written up in future papers but I will briefly summarise them here. He began by creating a circular buffer to continually capture the last fifteen seconds I had played. As it moved continuously with me, whenever I decided to capture (live sample) my own playing, the sounds I recorded were always exactly what I was currently playing. We then calibrated the system: the Polhemus system gave us two independent (wired) magnets, which we strapped to the backs of my hands. We placed the detection station to my back left and calibrated, to detect where my hands would naturally move playing the piano (by simply miming a variety of different pianistic gestures). We then set about creating particular trigger zones above the keyboard and changed the accuracy and sensitivity settings according to time and area covered, until they worked with real-time playing (ie if the length of time to take a reading

was too short then if I simply brushed through the zone I would create an unintentional trigger). We did a lot of work on creating appropriate visual feedback, on these sensitivity settings and so on but essentially managed to achieve four zones, two of which had incremental properties – i.e. they weren't just triggers but could be affected by which angle my hands entered the zone.

These tests allowed me to try out a very instinctive system, using the acoustic sound of the piano as the only sound source and in doing so, to see how the relationship of sensor control and piano playing would be altered by a unity of sound data. In early conclusions, I found this to be a very satisfactory gestural system – it was easy to manipulate and to make pianistic. The results of one of these tests can be seen online (Nicolls S. , 2011). This system in a way represented a return to the sonic landscapes of Barrett and Nono (in the close matching of piano sounds to the electronic part). Control-wise, it took me back to the closely linked gestural language of the Green, with the crucial difference that this time I could easily 'turn off' the sensors by not placing my hands in the particular zone.

2b Self-authored compositions and working towards a new piano

2.5 Publication 5: Nicolls et al – *Machines within machines* (September 2008)

This publication was a response to a commission instigated by Nick Bryan-Kinns and the Centre for Digital Music research centre at Queen Mary's, University of London (QMUL) during the Centre's first Artist in Residence programme. The output was to be a performance at the HCI 2008 Conference in Liverpool (HCI2008, 2008). I was asked to choose existing students to collaborate with and after a meeting and discussion with several interested parties, the students I chose were Adam Stark, Andrew Robertson, Kurt Jacobsen and Samer Abdallah, all co-authors of Publication Nine; this project is also briefly discussed in Publication Eight.

2.5.1 Methodology and Collaborative Process

This was the first time I had created my own solo composition in the course of the research so I was able to decide very clearly that the technology and the artistic aims would live on an equal setting – allowing me to definitely give myself control of the live electronics and also allowing the musical language to respond to the interactivity of the 'performance environment' I would create together with the QMUL team.

I decided that we needed to create a laboratory-type situation, so that we could quickly get to know each other and each other's work, that we could easily discuss the issues and possibilities, that we could have a space where we could instantly hear the result of different technologies being applied and so on. I therefore created something I called

'PianoLab' (see 4.3 for more details). Radical yet simple, the PianoLabs brought together researchers from different backgrounds in one space, with a piano and relevant materials, to research collaboratively.

Crucially, it placed creative practice centrally as a research method - seeking creative *and* technological solutions - and I found overrode differences in technical language between musicians and scientists: the live demonstration of a sound, action or technology significantly increased shared understanding between us, unhindered by having to find a common vocabulary to talk about things like processing or gesture. By both seeing and hearing at the same time the immediate application of a certain technological system to a certain passage of music I played, the research was allowed to develop in both directions at once: I could be influenced by the technology and the technological developments could be influenced by what the scientists heard resulting from their programming thus far. Adding in the use of interactivity, having all of the variables there at our fingertips probably saved us hours or weeks. This rapid response mechanism between the technologists and I also empowered us to challenge the limitations of the other's perspective.

2.5.2 Use of Performance as a Research Method

One very rewarding aspect of this project was using performance as a research method in and of itself. Doing work-in-progress showings opened up a more theatrical process, allowing feedback from real audiences to feed into the developmental procedure. I have found time and again as a performer that really until one has performed a piece to an audience in a proper performance setting, it will not have the chance to 'bed-in', nor will I be able to successfully judge whether I have truly understood the whole scope of a piece. In this project it especially helped to be able to try out the technology and see what communicated effectively to the audience in terms of interactivity. The technologists were very stimulated by having to create for real life situations so quickly and overall we found the intensity of PianoLab and the several in-progress performances to be a highly productive way to produce such a work.

2.5.3 Reflections on the artistic choice of the top hat

We decided early on to use a hat to embed the sensors that would give me my interactive control. One perhaps surprising result was that audience members didn't find this element ridiculous. Instead they found it communicative, engaging, theatrical, obvious but complex enough. Particularly valuable was that it was free-standing from piano technique and thus the playing of the two 'instruments' of piano and technology was straightforward for me: it was easy to separate the head and hands when necessary or to really combine them in a dramatic, almost indulgent way (for example playing the low bass notes when leaning my head right into the keys to create a low, rumbling grain delay). The only real issue with using the hat as a device for other projects was that long term it would be rather artistically limiting to attempt to make many performances of different music with a top hat; as the theatrical connotations of such an item are quite specific in their character, it would be hard to make sense of the allusion to magic in different musical realms that I might want to explore.

2.5.4 A note on identity

In making this first ever solo composition for myself to perform in public, I decided to create a pseudonym for myself. It felt appropriate that if I was to go on to create my own solo music, after years of being an interpreter and working almost exclusively with composers, that I should have a different label. I felt this would help to differentiate for audiences who might be expecting Sarah Nicolls the concert recitalist that here was something different. I knew I wanted my own music to grow from the Alexander's Annexe sound world and I had also begun to think about building my own piano (see 2.6).

I didn't want others to write for this instrument at first and on a purely practical level I also couldn't imagine how they could anyway, as literally no-one else in the world would have access to the same instrument - with a backwards but slightly randomised keyboard.

Having worked with Mira Calix, whose real name is Chantal Passamonte, I had become aware of what a stage name might evoke and I decided upon Tilly Automatic, which seemed to fit with my idea of the piano as an expanded machine and also reached out to a different kind of audience than might normally attend new music concerts. This was a deliberate attempt to abandon the labelling of 'serious' new music and engage in a different way with audiences – to have a persona which was bigger than me and which could embody something of the musical style I wished to explore. The name engendered a particular sort of attitude or mood, it evoked something perhaps light-hearted, punchy, extrovert. It also in some way allowed me to make the music without worrying if I was a composer or not, as I was now simply an artist like any other band or soloist – just making and performing my own music. I think crucially the name allowed me to feel free from comparison with the composers I had previously worked with and put me into a more self-taught musicians' bracket. The creation of Tilly also coincided with doing more informal gigs (in artist-led studios for example) and I experienced a sensation to explore more freely in these sorts of events, unhindered perhaps by references to previous performances purely as an 'interpreter' rather than creator of the music. The change of moniker did also spring from a desire to get away from the perception of new music as being simply a continuum of older music, so served to distance me from my own existence in the relatively normal settings of standard contemporary classical music concerts. It seemed vital to me (and still does) that music created now should be considered in a contemporary context – as well as concert halls and 7.30pm starts, I believe we should continue to seek out other relevant contexts for audiences. There is not space here to go into this debate but I think the creation of Tilly was also an indicator of this stance.

However, administrative complexities began to make me rethink and I also found being called Tilly at gigs quite disassociating: I realised that growing an entirely new identity both set me back somehow and also perhaps boxed me in to a particular aesthetic. Although the separation of identity had given me a freedom – the confidence and power to go out and play my own music - it also meant that I was splitting into different parts. I began to realise that I *was* interested in what other people might do with my piano. And if I was going to work with composers, which version of myself would I be?

After some deliberation, I decided instead to revert to my normal name and for each part of my creative output to seep into the other. This has resulted in a greater fluidity between creative situations and better continuity in my practice. The combination of having to practise diligently on a particularly hard piece and then go out and make a set of my own music makes for a healthy mix of experience rather than a reinforcement of the differences between those situations.

2.6 Publication 6: Nicolls – Music for Inside-out Piano (February – May 2009)

I was becoming increasingly interested in how the use of the inside of the piano might be aided by changing the shape of the instrument itself and in turn how this might generate new techniques or combinations of existing ones. My investigations into changing the fundamental shape of the modern piano hinged around one main issue: the 'inside' of the

piano being logistically inaccessible when performing extended techniques – i.e. directly onto the strings with one’s hands. Rather like a metaphorical iceberg, only the ‘tip’ (keyboard) of the instrument is available to the pianist, the rest ‘submerged’ behind the music stand, under the lid, beyond where keyboard and pedals can be properly used. Two problems spring from this: it is awkward for the pianist – uncomfortable at best, disabling at worst (e.g. being unable to perform both keys and strings at once). Normally one needs to lean at rather an awkward angle to reach inside satisfactorily – when standing this is very uncomfortable for any length of time and when seated it is difficult for relatively short-limbed performers as myself. The second issue is that the visual connection for the audience is lost as soon as performer plays inside the instrument: suddenly they cannot even see the hands of the performer and have to wonder at how these sounds might be being made. A third related issue, though not quite so fundamental, was that if I was interested in using gesture to control electronic manipulations of sound then I should really make it a priority to have these gestures visible. Thus if I was playing inside the piano with my gestures being read for interactive purposes, I had to make this section of the piano easily visible.

2.6.1 Description of method – creating the new piano

The making of a new instrument arose from the first PianoLab session. After considering the possibility that I might like to attempt to make a new instrument which I had been imagining for a long time, I sourced an old straight-strung upright piano, straight-strung because I knew that if I wanted to re-structure the piano it would be easier to maintain straightforward relations between action and string. Dismantling this piano I then hung the soundboard from the ceiling, in a performance event that was probably my first foray into theatre (Nicolls S. , *A public hanging!*, 2008). While the soundboard hung there for the ensuing month I was working in the space, and whilst using it as a extra resonating board and a place to try out inside piano techniques, I began to imagine re-attaching a keyboard to it.

I realized that as we had hung the soundboard upside down – really quite by accident as that was just the easiest way to connect the hanging rope – the keyboard would simply re-attach at the bottom, hitting all of the strings in this way (see Figure 4). Having discovered this I then had to think about how this new shape would stand, how the frame could be built, whether it would be possible for it not to topple over and how it might be transported. I had several additional pragmatic considerations that I was adamant about: 1) the piano would have to be able to be moved by non-professional piano movers; 2) it would have to fit through doors; 3) I would have to be able to move it myself within a room (i.e. it would have to be on wheels). The other main question was how I would play this piano – seated or standing? I decided the keyboard should be at a normal height but that meant the rest of the instrument might be taller and require standing (see Figure 5).



Figure 4. The piano in bits, showing how I planned to re-attach the keyboard

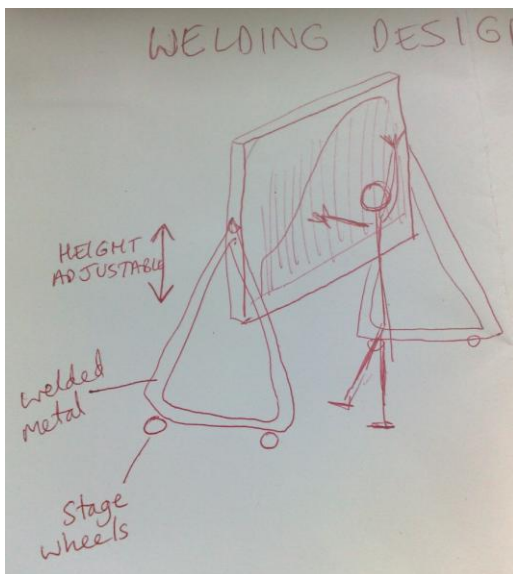


Figure 5. My initial rough sketch showing a possible playing position at the piano and key features

I contacted several fabricators before finding one (WRENIndustrial, 2008) who wasn't too alarmed at the idea of constructing a welded frame for a piano and willing to make the necessary structural calculations. The frame was then built and we spent time trying to refine how the action would re-attach, with room for adjusting the angle of the action and so on. There were minor changes that had to be made – such as hinging the horizontal steels that hold the keyboard, so the piano could still fit through standard doors easily – but essentially here was the first prototype (see Figure 6).



Figure 6. The finished instrument (photo by Neringa Plange)

The shape was actually quite similar to the old giraffe (PianoWorld, 2010) or cabinet pianos in terms of its relationship of keyboard to strings. The sound of the piano was retained very well (the *action* only missing about two strings in the whole instrument because of the metal struts being in the way). There was an absolutely fundamental problem with the whole instrument however, as the strings were in fact back to front: the bass was to the right and the treble to the left. I had ended up with this situation because the soundboard had been rotated through 180° and the reason for this was because I had had to find a point at which all of the hammers could strike the strings. If I had then tried to rotate the soundboard around its vertical axis. The hammers would have been effectively trying to play through the soundboard that was fixed behind the strings. Obviously with more money, time and a technician these problems could be solved (most likely through building a new instrument) and I have subsequently thought through all of the issues to prepare for the second prototype but with the very limited budget I had this was the simplest way to at least create a piano that played and to try out the fundamental shape and relationship between keyboard and strings. Needless to say though, as a performer this was quite an incredible mental challenge – more on this below: the only notes that were the same were A and E flat all the way up the instrument!

The other issue with it being back-to-front was that the dampers normally assigned to the bass were now effectively transplanted to the treble, so the bass strings rang out powerfully. I had of course also lost pedals and the hammers were also now hitting the wrong strings, according to their carefully stepped weighting. To summarise, this was a far from perfect instrument but structurally it was exactly what I had been aiming for and allowed me to begin experimenting.

2.6.2 Additions to the instrument

At the same time as wanting to address how to reach the inside of the instrument, I had also been struck by the idea that it

might be just as easy to get something - namely automated objects such as little motors – that could play the inside of the piano and which I would then in turn control. I had met Will Scrimshaw (Scrimshaw, 2008) at a one-day symposium at Culture Lab and after divulging my imaginings to him, he concurred there could be a lot of interesting discoveries to be made and offered to help make them a reality. We had several sessions over spring and summer 2008, trying to work out which kind of motors we could use, how they might be attached, what speeds might be best, what sort of attachments might work well or what kind of effects might be achievable with different materials. In the end we established a very simple fixing system for a grand piano – simply horizontal short planks laid across the metal struts to which the individual motor housings were screwed. The best materials we found were rubber for bass strings (this allowed the string to resonate without stopping it) and card or firm plastic for higher strings. The motors were small, 5v DC motors, with fairly limited power so we soon discovered that we would also need one gear head DC, so we were able to apply more force to power a stiff, plucking action.

The motors were then driven by software. At first Will created programmes in SuperCollider, whereby the individual motors were programmed to respond to particular frequencies. Thus, if I played an A above middle C, one motor would be set off but if I played a chord across several octaves, then two or motors would be started. There were (and are) infinite possibilities in the programme and though this is not something I have space enough to go into here, the main thing I learnt was what kind of response patterns could be built up. We also created a direct control version of the software, where I would be able to press a trigger and a pre-programmed rhythmic sequence would start and I could then speed these up or slow them down and layer different patterns. As the Centre for Digital Music project (Publication Five, see 2.5) came straight after Will's final visit, I worked with the Queen Mary programmers to use these pre-built sequences to form the basis of other models of textural control. The motors formed the basis for the beginnings of a system using remote playing of the piano and a more performer-controlled environment: again alluding to the 'Prospero-like' performer (Emmerson S. , 2007).

2.6.3 Performances given

The first performance I did on the piano was at the De La Warr Pavilion in Bexhill, sharing a bill with Hauschka (Hauschka, 2010). This was a purely improvised set and was done only days after working out how to attach the motors and bicycle wheel to the piano. The next performance I gave was with the poet Nathan Jones (MERCY, 2008). Ensuing performances included those with Future of Sound (Nicolls, *Machines within machines*, 2009); supporting MATMOS for the London Contemporary Orchestra (Nicolls, *Machines within machines II*, 2009) and playing with Tim Exile (Exile, 2009). Throughout I performed music I had created, collaboratively in the case of the duo performances or purely on my own for the majority. The music was now quite composed similar to the extent *Push Door to Exit* had been, with a structural layer of rhythmic and harmonic motifs pre-composed and then a layer of improvised material on top of this, usually involving the live processing elements. As the performances went on, I became more adventurous in mixing avant-garde language with the more rhythmically repetitive elements.

2.6.4 Reflections on playing the new instrument

Of course, I was stuck with the back-to-front keyboard. This was really a huge problem in terms of playing the piano in any kind of familiar fashion. With only the As and E flats being what I expected, attempting to keep hold of pitch was almost impossible and I had to stick stickers on every single note to attempt to learn the sequences upside down. Finding

major or minor chords was not too difficult as I could recreate the familiar shapes of major and minor thirds; however I wouldn't necessarily know which key they were going to be before playing them as the piano keys did not represent the note I would normally visually associate them with (a C key did not play a C string and so on). I do think though that this was something of a musical gain as it was quite liberating not being able to predict the tonality. It put me into a much more intuitive, responsive mode, not necessarily thinking before I played something so much as reacting to it after it had happened and once I found certain harmonies or pitches I could then refer to them repeatedly. This slightly blind approach to the keyboard had a big effect on what sort of music I began to create: being returned to what felt like beginner level whilst having the technique and sensitivity built up over thirty years of piano playing gave me a naïve and direct reconnection to listening to and experiencing the sounds as I played. Perhaps the most obvious direct musical result of this was that I often found myself repeating things, staying with what I knew was now 'safe' in some way.

Another interesting aspect of the keyboard suddenly being an unknown phenomena was that many of the normal and thoroughly learnt and trained-in aspects of piano playing – such as the right hand being more likely to play the 'tune' and the left hand more normally playing the accompanimental figures – all instantly disappeared. Although I had already spent ten years playing contemporary music that banished these traditional roles for the hands, it was still challenging to have them forcibly removed by reversing the pitches like this. For example, the control that was required to balance left and right hands was completely different on the new piano: my right hand no longer needed more projection as it was both playing the bass but also had no dampers to stop these notes ringing out until they naturally died. My left hand meanwhile was struggling with a treble that was being damped by bass string dampers and also somehow by the fact that the action just didn't seem to have as much movement at the treble end, causing the treble notes to be really weakened considerably in comparison to a normal piano. In short, playing it in any normal way was very difficult and again, this was both initially disturbing and later rather liberating.

As a physical enterprise, a new bodily experience and a way of connecting to the strings (which I had never been face-to-face with in such a way), the experience of the new piano was absolutely amazing, it was wonderful. First of all, the physicality of playing the instrument was so incredibly free compared to the contortions needed to play inside a grand piano. Standing straight and with the strings vertical in front of me, I could simply reach forward and play directly on them with no extra effort beyond lifting my arm. There was no back pain from having to maintain a position of 45 degrees to practise and no leaning over a music stand (although I clearly hadn't solved the problem of where the music would actually go).

There was also much less difficulty in perceiving which string was which – aligning vertically meant that looking up from the key, I could make a much better guess at which string was which note. Adding stickers also helped of course but the speed of comprehension (also without having to account for angled strings, as I had deliberately begun with a straight-strung instrument).

One of the most positive results was that it was possible now to imagine new techniques – more accurate playing of for example a key and the relevant string at the same time, thus creating new muting variations or a more virtuosic combinations of previously existing muting techniques (such as string harmonics).

Finally, the sonic experience was truly rewarding. Having the strings directly in front of my face meant that the sound reached me in all of its overtone glory, giving a much more realistic idea of what might be reaching the audience through amplification using very closely-placed microphones. It also enabled me to really close-focus on very detailed aspects of the sounds.

2.6.5 Towards sculpture

I hadn't thought about this aspect at all before creating the instrument – I was purely focused on it being a practical solution to technical problems I had encountered and future aesthetic aims for performance but once built, it soon became apparent that the instrument was perceived at first sight very much as a sculpture. Before a performance, I found people were fascinated by the object in itself and this gave me some insight into how visual artists think, their connections to their work, and the journeys that they undertake. Like composers, artists are encouraged to follow flights of fancy and become obsessed with particular things; the moment I realised I had started to think of the piano restructuring in this way (and that the output might not need to be pre-supposed before embarking on creating something) was an important moment in the development of the research trajectory.

I simply improvised: when seeing the motor rails added, I realised a cymbal would fit perfectly on the metal support poles and seeing this circular instrument then also gave me the idea of adding a bass drum: the piano became like a one-man-band, with a slightly absurd, playful look. I felt quite delighted that people responded so positively to the artefact. Some even began to place it into certain categories, such as 'steam punk' or homemade – aligning to the Open Source software community that was steadily growing at the time.

The main reflection here is realising that, as a visual as well as instrumental artefact, future prototypes would have to be built with the visual result as an important consideration.

2.6.6 Future aims for the instrument

There is not space to fully detail my future aims but I intend to make next stage prototype instruments, correcting the fundamental back-to-front keyboard issue, refining the way the action strikes the string, creating a lighter piano overall with innovations such as possibly folding the structure to make it more portable; ultimately to create a piano that can be carried by one person but that retains all of the acoustical and mechanical qualities of the current piano.

Setting out on this path of creating my own piano means that I am now perhaps in a more unusual or specialist position than before and now alongside these other piano-inventors, I suppose I am becoming more my own composer and improviser. Finding this new context, I was invited to curate a performance event and decided to use this to bring together a few of my co-inventors.

2.7 Publication 7: Sonatas, Pianos, Machines and Interludes (June 2009)

The project was an exercise in programming and event design, as I had come to the conclusion as a result all of the above projects that I needed to in some way curate my own context. What I mean by this is that I had realised I could go further than curating my own repertoire and present to an audience the wider context within which I was researching. I was focused therefore for this project on exploring the boundaries of installation and performance, self-playing and played

instruments, composed pieces and improvisation and my aim was for the audience's experience to embody the experience that I myself had had in inventing my own piano. In this way it sought to present visual delights alongside a mixture of musical languages and disciplines and give the audience a sense of what reinventing the piano might produce.

For the installation performance I brought together five piano re-inventors from across Europe and sought to contextualise my explorations into re-designing the piano. The artists involved were Andrea Neumann, Pierre Malbos, Kathy Hinde, Felix Thorne and myself, as both performer and curator. I chose the piano re-inventors by considering both visual and aural aspects, the aesthetics of each instrument and the set together as a whole. The event was shown twice: first at the Bluecoat, Liverpool (Nicolls, *Sonatas, Pianos, Machines and Interludes*, 2009) and again at King's Place, London (Nicolls, *Sonatas, Pianos, Machines and Interludes*, 2009). For the second event we were able to place beanbags in the centre of the room for the audience, with the instruments around them in a circle. Both programmes featured each instrument in a solo piece and one group improvisation involving myself, Neumann and Malbos. In between longer pieces, Kathy Hinde's toy piano performed music box pieces, created by punching holes along printed map routes signifying the journeys the performers had made to get to the venue.

As an exercise in both acknowledging and presenting the wider research context for altered or re-designed pianos, this project served to provide a tangible connection for audiences and a direct sonic experience for me during my exploration of the new Inside-out piano.

2c Written publications

2.8 Publication 8: Nicolls, S., (2009). *Twenty-First Century Piano*

This paper explained research undertaken to this point, including the first Green piece I performed – *Piece for Piano and Lamp*, the beginnings of work with Atau Tanaka, the setting up of PianoLab and the project with the Centre for Digital Music team (2.4). Presenting the paper at NIME, I gave evaluatory comments on each of the projects studied and this is included here (see appendix).

2.9 Publication 9: Nicolls, S., (2010). “Seeking Out the Spaces Between: Using Improvisation in Collaborative Composition and with Interactive Technology.”

This paper looked at how improvisation is used as a method in the process of generating collaborative compositions and performance systems using interactive technology. It comments on several of the projects within this PhD, giving some context to discussions of physicality here and process in working.

2d Composed pieces with improvisational, notational or other input from the author

2.10 Publication 10: Michael Edwards – *I kill by proxy* (December 2006)

This output was a one-hour performance of a work composed by Michael Edwards for piano, percussion and live electronics. The performance happened in the ZKM KUBUS, Karlsruhe, which houses forty-eight speakers. The piano was placed centre stage at the front of the space, with the audience looking towards it, seated in rows and the rest of the room was laid out in a clock formation: twelve ‘stations’ at which the percussionist performed were placed evenly in a circle around the audience. Edwards was in the centre of the room, spatialising the sounds in real time using a joystick.

Building on Publication One (which it followed chronologically), this represented further useful experience of learning *in situ* more about both collaborative composition and improvisation with live electronics. I improvised and recorded solo material for Edwards that became part of the electronic parts of the piece, also improvising with live electronics processes, to establish the most successful musical language for the piece. I was also asked to improvise with the percussionist, Stefan Froleys (Froleys), in a series of workshops prior to the composition process and also during the resulting live performance.

One of the most striking observations I made was that at some points in the piece it was decided that the effect of live electronics could be more effectively communicated by pre-recording the processed responses to something I would play then simply syncing the live and pre-recorded parts in performance by using chamber music communication (i.e. leading, nodding etc) between Edwards and myself. This was interesting to learn as I had assumed that this kind of ‘cheat’ would be easily spotted but not only was it not, it also allowed for greater sonic refinement of the processed sounds.

2.11 Publication 11: Larry Goves – *Piano Concerto* (June 2010)

This piece used exactly the same set up as Goves had designed for his original piece – ‘*My Name is Peter Stillman...*’. As I was already familiar with the performance environment, Goves was able to present new challenges to me and he proceeded to create a vast, half hour work which also incorporated a second movement played on prepared grand piano, separate to the first instrument. Going back to the performance environment for the second time was easier of course but now had new challenges, such as greater integration between the two keyboards – i.e. more mixed playing, where each hand was on a different keyboard. In particular the third movement took this to quite complex levels, dictating dense hand crossing. I found here the notational layout became even more important and asked Larry to swap the keyboard and piano parts, taking out altogether the written out version of the electronic keyboard (see Figure 7). Having the keyboard part at the top made much more sense cognitively – relating as it did to the geography of the keyboard’s actual positioning on the piano.

The image displays a handwritten musical score for an electronic piano (e.pno) and a piano (pno). The score is divided into five systems, each with a double bar line on the left. The systems are numbered 137, 145, 147, 152, and 156.

- System 137:** e.pno (played) and pno. Annotations include "STRONG SPRING" and "LH". Dynamics range from *f* to *ff*.
- System 145:** e.pno (played) and pno. Annotations include "STRONG" and "ped.". Dynamics range from *f* to *fff*. A note at the end says "*press notes silen".
- System 147:** pno. Annotations include "G# E F A" and "3 4". Dynamics range from *pp* to *f*. A note at the beginning says "*press silently".
- System 152:** e.pno (played) and pno. Annotations include "RH", "LH", "MIRROR", "PLACE IMPULS", and "animate hand on piano". Dynamics range from *f* to *fff*.
- System 156:** e.pno (played) and pno. Annotations include "6", "2-6 (m)", "strong", "mp", and "005...". Dynamics range from *f* to *p*.

Figure 7. Showing the re-ordering of the electronic, keyboard and piano parts (compare with Figure 3).

3 Improvisation to notation: alternative creative processes

The exploration of new notational methods should aim to make what notation is for (communicating a musical idea from one individual to another) more efficient, more creative perhaps, more collaboratively engaging; ultimately the most successful it can be, according to whatever criteria are in place. Recently I had the experience of playing in Anton Lukoszevieze's *Entropic Song Meditations* (2010) (Lukoszevieze, 2010) and it was fascinating to see a semi-composed score (see Figure 4) written by a very experienced performer. The way that the visual presentation of the score (i.e. curved staves, splashes of graphic information around note heads, notated music with right and left hand staves not adding up) seemed to fill in for any 'missing' notated information seemed to communicate above and beyond what could have been as successfully communicated in a traditionally notated score. The flexibility however was married with enough information to allow us to perform the piece within effective enough parameters so as to allow repeat performances to remain true to the intended spirit of and characters within the work. The use of stopwatches for timings and separate movements further sculpted the structure into meaningful portions that could be assigned with certain musical characteristics.

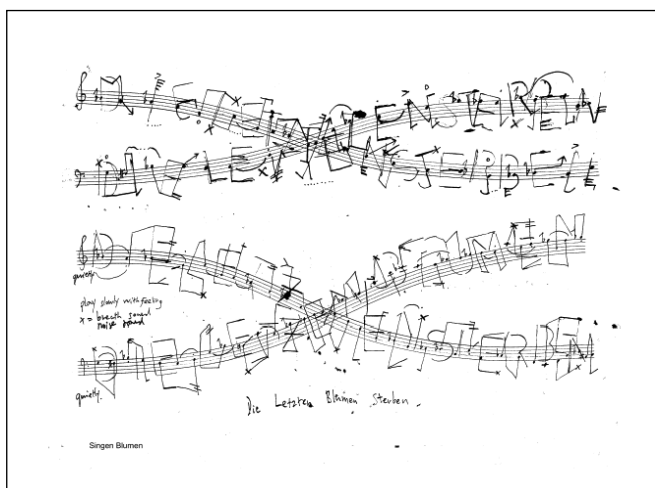


Figure 8. An example page from Anton Lukoszevieze's *Entropic Song Meditations* (2010)

As referred to several times in this document and the written publications, I realised after Publication Three (2.3) that to create new notated pieces for the interactive live electronics idiom, I would have to take a much more active role in creating the pieces: it seemed to need a collaborative compositional process. Using my own physicality to have interpretative license over the electronics seemed to demand something different to following the traditional commissioning process, whereby a composer works discretely and presents a completed piece to the performer to then learn, interpret and play.

3.1 Difficulties in notating live electronics

Referring back to 2.2.8, the difficulty of making pieces that could be passed on and re-created easily (or remotely) by

other pianists was mostly a notational issue. The attempt to capture all of the information that would be needed to guide either a pianist or a technologist to recreate the live electronics in these pieces proved to be too difficult for most of the composers in this project. That a lot of live electronics works performed by their creators are not notated in any useful way is clearly an indicator that this is a challenging problem. Even tape parts, which will remain exactly the same in each performance, often fail to be notated in a clear or useful way: composers often opt to print the sound file wave shapes, giving no indication of textural change, only volume. These representations are – I would say and have found – in practical terms not much use to the performer and simply take up precious space whilst providing no really useful information, so I therefore often cut them out of scores, replacing them with more descriptive words, or a mixture of normal notational devices and graphic shapes.

The pieces in this thesis which were notated to the point where they could be passed over to others, without extra verbal or written instruction, were the Goves, Green and Clarke (with Dudas' patch addition, allowing the performer to trigger the patch changes). These pieces either had limited parameters for the performer-controlled interaction (such as only one parameter but without specific control over how it was used as in the pitch bend of the Green) or were entirely keyboard-based and could thus be notated normally. In other cases it would not have been so easy to create a notated score for the electronic parts of the music: a notated part for the live electronics in Barrett's *Adrift* (2.2.2) for example would be comparable in its complexity as the piano score of Barrett's original *Lost* (2004).

So how can one create pieces with live electronics that can be played by people who are not the original creators? It is of course possible to fully notate pieces that use interactive environments, but it depends very much on how the interaction is designed and the parameters therein. Clearly, in the case of pieces using normal notation and responding software (processing the played part live such as in Clarke (2.2.4)), then a high degree of accuracy can be achieved in play back: as long as the pianist plays what is written, the computer response will always be the same, comparable to the reproducible nature of any traditionally notated piece. However, if the interactivity is more like Tanaka's muscle control (2.4.2) then communicating levels of intensity mixed with gestural shapes over say just two sensors already becomes more complex.

3.2 Finding solutions

Finding notation that relates to pre-existing language but that can be applied to, for example, a different physical output I have always found to be most effective. A good example of this would be the crescendi and diminuendi for sensors in the *Valves* score by Hugo Morales. The development of notation occurs best, in my opinion, in an iterative process between performer and composer and I wanted to illustrate how effective this can be. Below are the stages of both pieces created with Morales, showing the refinement that happened after our collaborative sessions. Although Hugo would have increased the information anyway - as the first score in both cases was an initial draft to begin our collaborative process - it is interesting to consider (or be reminded of) how a collaborative process may very usefully influence what is added from session to session, especially when dealing with very extended techniques.

Figure 9 shows the first draft score for *Espacios Encordados*, below.

I Press switch to start

EVERYTHING FORTE - like a typewriter going to next line

good w/v. short breaks

work towards full-type gestures

20"

35

46

from lowest note in between top staves (on my piano = A)

CHEAT = stick buttac below

always from lowest note

ppp sempre

SWITCH 1

54

59

62

2" 2"

1'20"

Still dense but quiet, except forte accents

fff

ppp

"random chud"

Pd Pd etc.

These notes = all same pitch & ff

> = keep ped on slightly longer than note

150

where $\dot{=} 60$

2"

1"

... 10"

TRAIN left foot!!!

Tip = after LH pizz, hold hand there to 'catch' sound

Quite a lot of movement & activity

40" app.

Plucked

amps closed

SWITCH 2

open amp. progressively

60" app.

Plucked

1

aim: to create almost continuous ~~build to~~ ~~noise~~

II

now only 'playing' speakers

pizz.

60"

Add resonators progressively

going down pitchwise

amps in 0

open amps. prog.

2

switch

3

Figure 9. The first draft score for *Espacios Encordados* (2008) by Hugo Morales Murguía

After working together in our first session using the above score, I then made notes (Figure 10) as to the extra information I felt was needed; these notes were shared with Hugo.

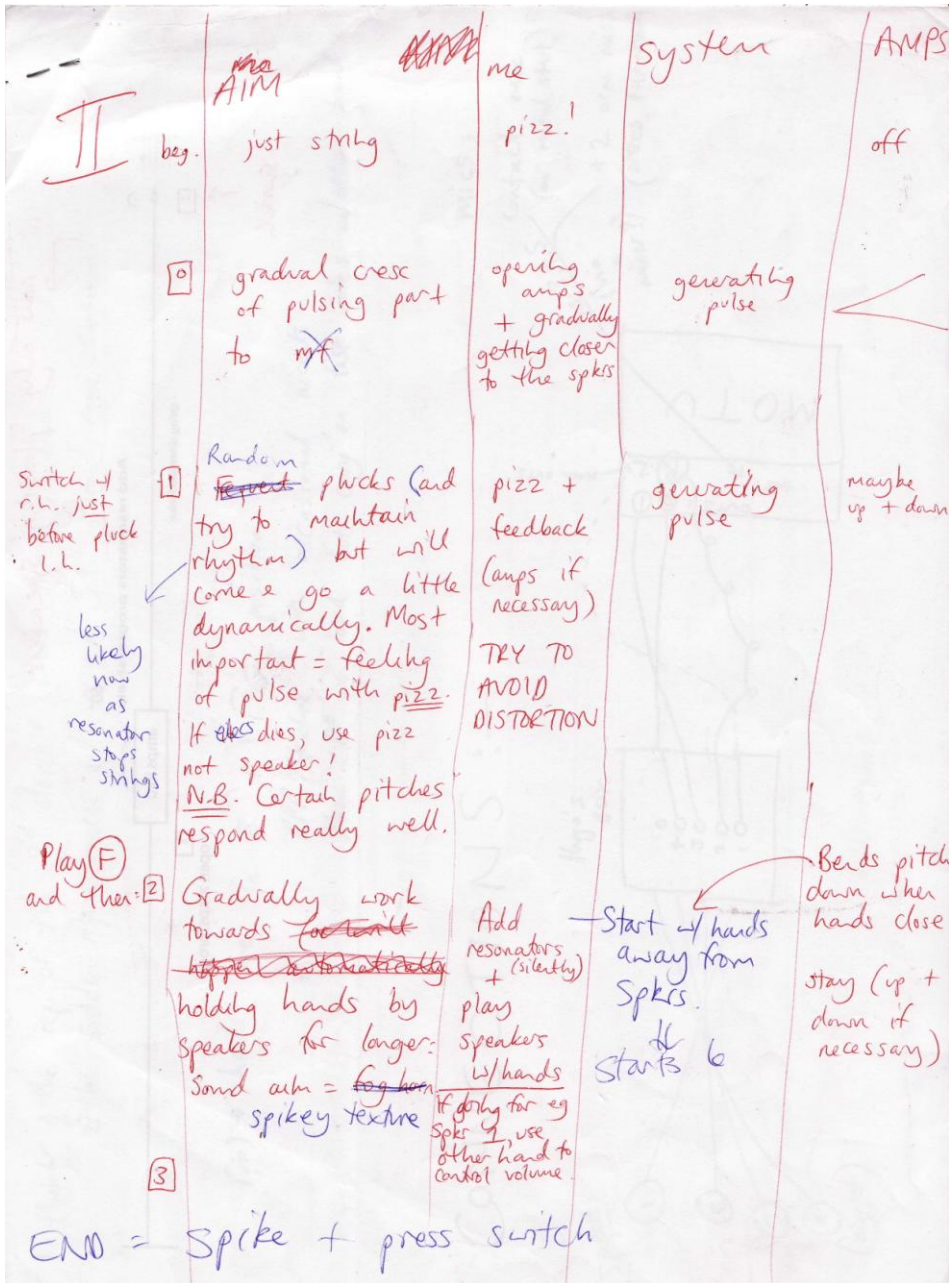


Figure 10. My notes after the first working session for *Espacios Encordados*

I found approaching each element (either a direct input or a resulting characteristics) like this simplified what I immediately controlled and what resulted from that control. By separating the elements like this, I hope I was also able to clarify for Hugo what the next iteration of the score might need to look like (Figure 11).

to Sarah Nicolls
espacios encordados
 for feedbacked piano

Hugo Morales Murguía

espacio I

Muted
 amplified piano (no digital manipulation)

20" 15" 11"

fff Fast and incisive random "clouds" of attacks, trying to avoid any gaps between them.

8" 5" 3" 2" 2" 1" 1" 15" *ppp* STeady

30" 1" ... 10"

fff *sim.* *ppp*

espacio II

2

Inside the piano (sustain pedal down)
 amplification + digital manipulation

(40") (60") etc...

Plucked

Pluck the string progressively opening each amplifier while waving both hands, shortening the distance between loudspeakers and wrist microphones, provoking a subtle feedback arousal.

Plucked LH

Feedback RH

Pluck any string within the indicated range while controlling the level of feedback with the other hand

switch

switch

switch

switch

Plucked

progressively, and extremely silent, add metal objects on the strings

Pitch curve

Distance between microphone and speaker

(2'30") Pulses

Vary the distance between microphones and speakers evolving from a stable pitch continuum to an irregular and unstable chaos, by progressively shortening the distance between microphones and speakers as well as by adding light metal objects on the strings.

Figure 11. The final score of *Espacios Encordados* (2008) by Hugo Morales Murguía, showing much more detail than the first version

It is obvious that there is much more detail in the finished score and it is especially of note to see that physical directions (such as where to stand and how to move in relation to the piano) became part of the score. I suppose the main point is we perhaps don't know what we do naturally without thinking until we give the information for someone else to recreate and Hugo passing his extended technique pieces on to me forced us both to confront how much information was needed for me to successfully recreate his very natural exploration within performance systems he had both designed and then discovered further through improvisation.

Figure 12 shows the first (draft) score of *Valves* that Hugo presented to me in our first working session.

Starts with: beginning: e-bow on // SILENT MODE // Resonators on strings.

Blutac on bottom 2 + top 16 notes

1 Disklavier Solo (Silent Mode) *NEED = stop watch*

3 1/2' max

2 Pianist: Prepared: Ebow on E6 Blue tac (high and low range) *NOISE + ebow* *ENTR* *15".ca* *1. 2. 3.* *SIT* *Hit Key* *10".ca* *(TACET)* *etc..*

Diskla: noise in E *etc..*

3 Pianist: *Close Fallboard (keyboard lid)* *Slowly press middle sensor and progressively the rest* *Change notes slowly by pressing C 220 11 times* *(TACET)*

Diskla: *1567 Hz. (G7)* *noise* *etc..*

4 Pianist: *Walk to play inside the piano* *Slowly touch strings with transducers*

Diskla: *Slow random notes* *Low Freq.*

versions by try *bang up* *right ped AT* *last pedal change* *turn off ebow* *3rd ped* *hold ped w/ ebow* *then put per in to hold keyboard lid.*

IMPORTANT: hold l.h. note while setting up 3rd ped trigger

U.C. for rptd note speed *Alternate and combine p and slow* *TRIGGER for end of section* *2 1/2'* *2B* *1567 Hz. (G7)* *1567 Hz. (G7)* *C 220 1/2 for 5'* *etc..*


Make this bit longer: the 8th trigger is the first bass note *Sine waves = note frequency* *Low Freq.*

try to get close to resonators (since have fades in) *AND open keyboard lid.*

AIM for pure sounds at base (cross down abd of switches)


Figure 12. The first (draft) score of *Valves* (2010) by Hugo Morales Murguia

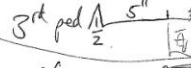



I again made notes for myself after our first working session during which we had worked with the above score (Figure 13).

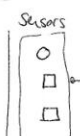

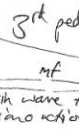
Set at start: SILENT mode ON. elbow ~~press~~ on . Blu tac on . Pianist offstage or in audience

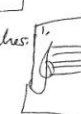

1 Disclaimer Solo for approx. 3.5 mins final cue =  Then: ~~press~~ 5" then ENTER ROOM, walk to piano, subtly turn off silent mode + SILENT 




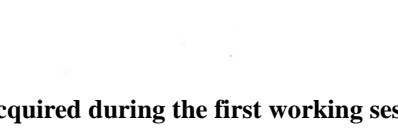
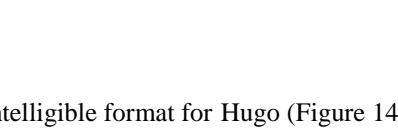







2     NOTES: 1. r.h. repetitions only: sound when both note is held and l.h. depressed.
2. At first, sparse with silences between but building to continuous texture (not with volume of l.h. though: quite flat expressively).

3  Close lid by starting close motion: itself allows lid to close itself

final trigger:    

SENSORS    mix s.h. wave + primo motion

Pitches: 1.  2. 

HUGO TO WRITE + w/dyna            

4 Lock r.ped. Placing hands on piano frame for balance, lower yourself to add pedal holding object:  Move slowly around to bow/bell 

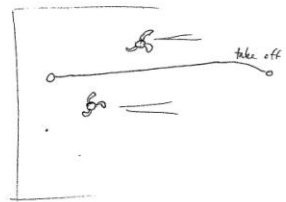



Figure 13. My own notes, showing all of the extra information I acquired during the first working session with Hugo.

I then worked in detail to write these notes up in a more legible and intelligible format for Hugo (Figure 14).

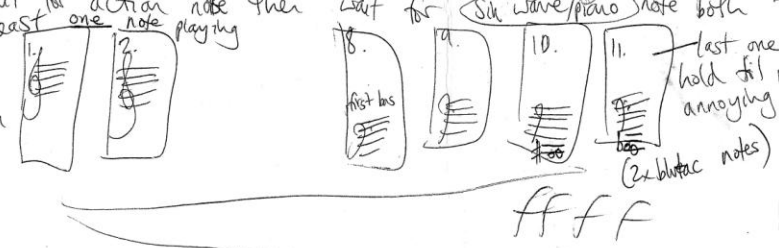
"Avoid intervallic relationships here: isolated notes)

28) L.H. long/held notes but non-legato; only down to 
 R.H. d notes (blend into sp. d. notes) whole notes held

Gaps - at first but once built up, keep it continuous.
 First 30" play \leftrightarrow r.h. (x2 notes) + ebow (via right ped. \leftrightarrow); then introduce l.h. (noise) (build to)
 + then vary more the order of things: so eg. r.h. note ① - l.h. - ebow - l.h. - r.h. note ② - l.h. ① - etc.

3) v. intuitive control! (where d 28 left but really tricky...)
 Wait then wait for action note then wait for Six wave/piano note both to be heard.
 Always at least one note playing

Write like:
 each section min. 3"



last one hold fill! annoying!
 then listen to resonance without moving. RITUAL

MOVE to put per ly pedal like the RITUAL

4) Avoid mistake noises (e.g. setting off strings by sort of plucking w/cork).
 Use exploration of length of string.
 At end: walk away after 3'

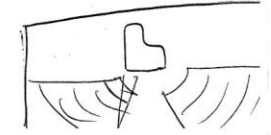


Figure 14. The notes I made and passed on to Hugo, for him to work on a second score for *Valves*.

Having tried working with the first score and with the above notes added to the process, Hugo and I continued to have in-depth discussions about what information was needed to recreate what he was imagining – which pitches I needed, which didn't matter so much; also how to best present the information on what was triggering what (for example, the high Gs in section 2). In particular we came up with a new notation for the pressure sensors that were placed on the keyboard lid in section 3. Figure 15 shows the first four pages of the final score, with my performance markings on them.

When SILENT on, not poss to see hammers.

CHECK LINES

To Sarah Nicols
Valves
for disklavier, pianist and electronics

Hugo Morales Murguía
2010

A Disklavier Solo
Silent Mode

B (Second part)

Electronics: Noise simile

Pianist: (9 diff dynamics/speeds)
3rd TRIGGERS elec to stop

Annotations: TRIGGERS, 8va!! (pink), ff = MAX but max is ~mf, SILENT OFF! (Wait til noise v. low), G 8va E loco, HOLD L.H., Right ped, U.C., Loco, P.L. Loco, V.C. 1/2, 5th, 3rd, 2nd, 1st, 4th, 5th, 6th, 7th, 8th, 9th, 10th, 11th, 12th, 13th, 14th, 15th, 16th, 17th, 18th, 19th, 20th, 21st, 22nd, 23rd, 24th, 25th, 26th, 27th, 28th, 29th, 30th, 31st, 32nd, 33rd, 34th, 35th, 36th, 37th, 38th, 39th, 40th, 41st, 42nd, 43rd, 44th, 45th, 46th, 47th, 48th, 49th, 50th, 51st, 52nd, 53rd, 54th, 55th, 56th, 57th, 58th, 59th, 60th, 61st, 62nd, 63rd, 64th, 65th, 66th, 67th, 68th, 69th, 70th, 71st, 72nd, 73rd, 74th, 75th, 76th, 77th, 78th, 79th, 80th, 81st, 82nd, 83rd, 84th, 85th, 86th, 87th, 88th, 89th, 90th, 91st, 92nd, 93rd, 94th, 95th, 96th, 97th, 98th, 99th, 100th

Electronics: 8va, Loco, ff

Pianist: 8va, Loco, mp, p, HOLD G ->, only i.h., Right ped ->

Electronics: 5th, Play Loco 8va...

Pianist: V.C., C, HOLD!! Loco, R. Ped., HOLD FIRM (if noise goes, re-trigger), HOLD right ped, take hands off gracefully, allow lid to close itself, V.C., 3rd, 5th, when starting here, press both Gs

Working with Hugo on this second piece was advantageous as I knew from the earlier experience that we needed to establish a better method for communicating in words or symbols what he actually did when playing with his invented ‘performance environments’. In both cases, the notation was fairly sparse but the textures of what he wanted were actually quite specific. Through discussion for example we discovered that the notes for the repeated notes section towards the end of section 2 needed to refer quite explicitly to texture, whereas he had thought this just needed improvising. There is an important point here about one person improvising and getting used to what they find and then expecting someone else to find the same thing.

I would say Tanaka also experienced this – in his improvisations he had found certain sounds but in notating these we discovered there was quite a need for discussion to really communicate the fine details, such as angle of the hands and so on. Using improvisation, I found Tremblay’s score extremely clear and I think this is both because he had very clear ideas about what I would need to know as a performer and what would be helpful but also because of the process we underwent to create the piece. I remain convinced that the combination of using improvisation to find a common language, or even just a common way of talking about musical language (refer specifically to Case Study 2 in Publication Nine, 2.9) during initial stages of the process, really helps to reveal to both the composer and performer what might be necessary for each to understand the other’s intentions.

Clearly, if this had to be the case for every new piece created by a composer and performer it would contradict the original aim to create notation that could be widely understood. But I believe this conversation creates something that *is* universally useful: performers and composers often have different perceptions of what is useful for a performance to really work and if this discussion can occur during the *creation* of a piece, then these different needs can be best represented in the final score.

See Publication Nine (2.9) for more on this discussion.

4 Processes of working

4.1 Collaborative generation of interactive pieces

My conclusion (see 5.3) that physicality must make sense in some way has led me to conclude that the collaborative generation of interactive pieces is likely to be more successful than a composer working totally in isolation. The possibility that this close joint process specific to two individuals then creates a piece that cannot be transferred to other players is hopefully answered by careful discussion and collaborative creation of a score during the process. In creating *Machines within machines* (2.5) I was privileged to create the whole system (both the performance parts and their technological set up), meaning I could intuitively explore each system whilst allowing the physical experience of the technological interaction to inform the aesthetic goal. By working with composers, this same cohesion can be achieved: by moving into a more collaborative situation, performers can be part of the creative process, feeding in their own expertise to the creation of the piece.

I would also argue that allowing interactive live electronics pieces to grow out of the technology is essential. Instead of creating a musical goal and a performance environment (or even the requirement that there be interactivity) and then hoping they will work together has clearly been shown in several cases in this PhD not to work. By including the physical engagement of the performer in the process of creating the piece adds another tie to make this more achievable.

4.2 Using electronics as an instrumentalist: pragmatic considerations

The situation of live electronics is obviously much more precarious than working only with a grand piano where, apart from a string breaking, the danger of something going wrong with the instrument itself is highly unlikely. On concert days it is possible that the whole rehearsal/sound check will be used setting everything up and checking the technology and this can be unnerving if not anticipated. I think harder to get used to, from an instrumental performer's point of view, is the painstaking process of getting used to managing and working with the technology in rehearsal, where one is usually alone. In this context, the technology can be extremely disruptive: instead of being able to sit and play for a couple of hours, there is more than likely to be several hours (sometimes each day until a system is secure) of pressing different buttons, wiring things together and trying to solve the problem with remote technical support. Although these disruptions are perhaps seemingly trivial and just par for the course, they can really get in the way of properly absorbing the music and getting deeply into the musical language to internalise it ready for a performance.

Of course, different collaborative partners will be able to create different levels of security in their 'performance environments' but for example if a brand new idea is being tested then it may need to go through several iterations before settling into something reliable. I would say this strengthens the case for working in laboratory-type situations, not least so that equipment can be left set up and plugged together.

4.3 PianoLab: a model for interdisciplinary research

There are several places where I write about the PianoLab methodology that I used throughout these projects. In total I had five main PianoLabs during the course of this research: in Wolstenholme Studios, Liverpool; at Newcastle University; Mivart Studios, Bristol (hosted by Kathy Hinde); the University of Cincinnati (hosted by Mara Helmuth) and

at CNMAT (working with Michael Zbyzhinski). Each of these gave an opportunity to do cross-discipline investigations, usually either building or testing a certain piece of technology. At PianoLab CNMAT for example, we created a unique inside piano controller using conductive fabric stretched over the metal struts of the piano; enabled by chance conversations and combined expertise, this would not have occurred without the PianoLab environment.

Currently a roaming laboratory, PianoLab can be placed at the heart of institutions across the world, accessing different perspectives and creating a global, personal, collaborative framework. Since host researchers are working in a familiar environment, time is used productively as researchers have access to their regular research materials and environment. Other benefits include involving other colleagues such as senior staff and visitors otherwise unable to commit to (or indeed be funded for) the PianoLab working period.

4.4 Theatrical ‘work-in-progress’ benefits

In several projects, especially the work with Atau Tanaka, I have used a more theatrical work-in-progress process to build pieces up for performance. An uncommon method for musicians, this process entails giving showings of a work before it is finished, to receive feedback from peers that is then used to improve or develop the work for the next performance. I have found this to be entirely suitable for interactive work – allowing a performer to get used to a new system in more regular, informal settings and also to receive direct audience feedback about the communicative powers of the chosen system. I think it would be extremely healthy if the musical community were to embrace this more step-by-step process, as it is useful from so many angles: to allow the performer to try out ideas and discover if they ‘work’ to some extent, to give performer’s feedback from a real audience, to bind the creative community together and to stimulate further ideas in the presenters and perhaps also the audience too.

Other projects which I have not had space to include here, include the collaboration *Black, White, Grey, Cream* (2010) with composer Claudia Molitor resulting in performances in Bexhill (Molitor&Nicolls, *Black, White, Grey, Cream*, 2010), Liverpool (Molitor&Nicolls, *Black, White, Grey, Cream*, 2010) and Brighton (Molitor&Nicolls, *Black, White, Grey, Cream*, 2010) and the collaboration with theatre maker Augusto Corrieri (Corrieri&Nicolls, 2008).

5 Conclusions

5.1 The technique of interactivity

Using interactive electronics, such as gestural control, I have discovered that it is hard to produce pieces that are pianistically interesting whilst also being interactive, with any degree of finesse of control in the electronics. Wearing the sensors is not problematic; the icube (InfusionSystems, 2009) system I was using is extremely light, less than a small box of matches, so there is no physical disruption technically to the arm. When sensors are placed well, in line with the muscles and not too tightly, they cannot really be sensed if one is engrossed in the music³.

However, what is disruptive or challenging is learning a new gestural language, whilst retaining pianistic control or freedom. For example, in Green's *Into Movement* (2.2.5), because I knew bigger gestures meant more pitch bend, I learned to play without moving in a vertical plane at all, in a *flat* way - using horizontal movements instead of an arch motion to jump from one chord to another - if I wanted to activate less pitch bend. This is interesting, as Green had actually notated quite carefully where he wanted more activity and where less but even so, I still felt there were gradations to be found within these boundaries.

In Tanaka's piece, *Suspensions*, the introduction of tension as a control mechanism creates a complex impact on piano technique. It is potentially very problematic, if a pianist is playing and simultaneously tensing the whole forearm then both the resulting acoustic sound is going to be quite harsh, the control over the acoustic instrument will be lessened but there is also a danger of creating actual physical problems, hence my seeking the advice of a physiotherapist.

Another interesting issue that arose was when Tanaka wrote fast passages: we imagined that it would create a lot of muscle activity data but in fact these passages created next to no reading. We very quickly realised that this was because the pianist is trained to maintain the highest level of relaxation whilst giving out lots of energy – done by creating sudden peaks of energy, quick bursts. Because the arm was effectively in equilibrium, the arm's position was also maintained fairly still whilst the fingers move rapidly, so the bigger muscles were also not affected. This might perhaps be similar to putting a sensor on the shoulder of a running athlete, imagining that they will go up and down a lot, where actually they run smoothly.

The entire experience of working with sensors revealed or reinforced useful information about the fundamental characteristics of piano playing. The sudden peaks of in the sensor data readings showed my technique was behaving as it should fundamentally: the muscles quickly and decisively achieving their goal and then returning to rest as soon as possible. All performers will no doubt have particular characteristics and as pianists it seems we are trained to give very accurate threshold readings (certain levels of energy followed very quickly by relaxation below the point of the threshold). Thus, if playing a passage with for example several staccato chords of different dynamic levels, a pianist can accurately recreate readings according to a particular passage of music. These sorts of specific situations where we can say a *fortissimo* chord followed by a *mezzo forte* chord will produce *X* and *Y* readings, which can then be applied to control *X* and *Y* effects.

³ I would liken it to wearing contact lenses – at first one notices, then after a short while it is not an issue.

5.2 Performing two instruments at once

Asking what the purpose of a gesture is creates a double-edged sword. Attaching a sensor to a pianist's arm gives the arm two outputs, which are potentially physically juxtaposed: although both happen as a result of making sound, one is dictated by action towards an external object and one is created from internal mechanisms (ie muscle readings). These could perhaps be labelled 'resultant' gestures (resulting from attempting to achieve a sound through an external object such as a piano key) and 'active' gestures (actively pursuing a sound purely through the shape of the gesture itself). Miranda and Wanderley (2006, pp. 5-10) examine several alternative labels for these varied gestures in their excellent book. This two-way situation is confusing for the brain of the performer but, when it works well, one can sense an interesting dialogue within one's own arm and play with it. The frustration can be that when wearing sensors such as accelerometers, which are reading the movements of the arms (rather than the tension within them), the sensor cannot be 'turned off' - as in the example (2.2.5) of learning to avoid Green's pitch bend.

Also, if one is thinking 'is my forearm tensed enough?' then the piano playing is bound to suffer. If half of the time the pianist is thinking about the gestures that are controlling the sensors, then half of the time they are not thinking about playing the piano. Although I consider the gains to be enough to work through these issues (gaining the space around the keyboard as a controller, or hints of theatricality, or the extending visual impact of the performance), it is also good to be aware of any particular trade-off, like this, that might occur.

I have found therefore that the two most common scenarios of playing piano whilst wearing sensors are:

- 1) I learn to play the piano with a kind of muted physicality, so as not to send undesired readings;
- 2) I find gestures that can occur extraneous to the piano playing, to find the 'spaces between pianism' in which to stimulate the sensors.

I have also found that a kind of exaggerated playing style, so as to deliberately expand the physicality of performing to send readings, also works really well. This in turn can make space for a theatrical language to emerge: in Tanaka's piece, when performing a pitch bend with the sensors at a particular point, I found the level of tension that was needed could be created by a sort of pulling motion, which also made sense psychologically to me in relation to the sound that was resulting in that passage.

Of course, 'active' gestures like this may create associations for an audience: I might be making a particular motion to create a sound but the observer might think - 'this looks like she is picking fruit from a tree'. In this way, how gestures look from the outside is another responsibility that the performer has and should be aware of: in using interactivity to control sound, we have strayed into a dimension where everything suddenly can have an extra, theatrical meaning. Playing Tanaka's piece to a theatre audience in the informal showing without a piano (Nicolls, 2009) (mentioned above) allowed me some insight into this: the observers there placed all sorts of meaning onto what I was doing. I realised through their feedback that I was creating multiples of gestural meaning, rather than focussing on examining the relationship of piano and electronic *sound* that I had initially set out to explore. Instead, what I had been made acutely aware of was the phenomenology of the gestural language created in any particular performance and going on therefore, how important it was to consider the possible meanings of extra-musical gestures made in interactive electronics, as much as the sounds one is searching for.

5.3 A question of style – should we show what the interactivity is doing; does it matter?

Going back to the reflections on the Green (2.2.5), I have found it is important to continuously go back to the basic question: ‘why live?’. I would argue that the main reason for using live electronics is to communicate sound more clearly (perhaps more visibly) to an audience and secondary to that, to give more interpretational freedom to the instrumental performer. There are of course other benefits, such as accessing sounds that don’t have to be notated or which are created easily by spontaneous responses but fundamentally the point of live electronics, in my opinion, is that they offer a more physically communicative channel through which the music can be passed: a live connection to the music.

The reason (after receiving feedback about Green’s *Into Movement* being hard to understand in terms of interactivity) I had deliberately created a system that was obvious, was precisely for the benefit of the comprehension of the audience. I wanted people to see the connection between sound and physicality. Very much in the traditional instrumental paradigm, I felt this added a dimension to the performance that, with ‘invisible’ electronics, might not be there.

So, here is the conundrum: do we want to explain through the performers body what the electronics are doing when we use interactive performer control? The simple answer would be all manner of solutions will work and produce good artistic results and especially if the connection of physical movement to resulting sound is deliberately subverted for theatrical or other reasons then a performance can be extremely effective, as in David Bithell (Bithell, 2005): I am certainly not arguing here that it is necessary to always have constant one-to-one relationships of all gestures and sounds. However, asking this question as a summing up of the research I have undertaken and in reference to the work that it involves, my conclusion is that if physicality is being used to control something then it *must* make sense in some way, it must have a relationship that can be comprehended by an audience.

There are other reasons for creating performer-controlled systems of course – greater interpretative freedom being an obvious one – but fundamentally, for me, interactivity is tied up with communicating to the audience. When one sees a performance where there may be generous arm gestures (say where infrared sensors are being used) that can easily be perceived but the correlation between them and the resulting sounds or visuals cannot be understood (perhaps the sounds seem to respond to the arm when it is moving but then the arm stops and the sounds carry on exactly as they were), then this causes a real cognitive problem. The observer wants to rationalise or make sense of the relationship between something he or she can inherently understand (knowing how it feels to move one’s arms through the air in this example) but when this link is broken there is a real problem of broken perception: the rules that have seemingly been set up are broken but with no obvious reason⁴. I conclude that physical interactivity must carefully consider this perceptibility from the audience’s perspective. Although the top hat (2.5) may be a rather extreme version of something obvious, it creates a relationship that can be quickly understood and then experienced in a tangible, physical way by the audience. Similarly, an audience can also understand witnessing the tensing of an arm muscle physically: they comprehend the feeling of tightening and then hear these responses in the music. In these examples we are getting close to Emerson’s vision of the ‘Prospero-like’ (Emerson S. , 2007) performer and giving a real reason for seeking out physically interactive solutions.

⁴ We are not talking here of deliberate aesthetic choices, whereby a system is set up and then deliberately subverted, as in for example David Bithell’s theatrical performances (Bithell, 2005)

5.4 Achieving aesthetic balance

I learnt, through various publications in this thesis, that it seemed appropriate to balance the complexity of the technology with simplicity in what I was playing. Though this is strictly an aesthetic choice, it is born out of the discoveries I have made, especially talking to audiences after performances and I therefore feel it is worth mentioning here. Having made the choice that interactivity *should* be understood: if the music I play on the piano *and* the processing I simultaneously control live are *both* very complex, the comprehensible connection between gesture and sound *can* be lost. To say this more clearly, if I play many notes in an atonal and arrhythmic language, and simultaneously use a top hat (a relatively simple interaction) to control grain delay (relatively complex processing) then the benefit of the top hat's simplicity *can* be lost.

According to audience members who saw early performances of Publication Five (before I simplified the musical content), this was the case. I also felt the issue myself whilst performing: trying to keep track of three complex elements made it too hard to perform intuitively with the connections. If I instead changed the notes being played to simpler musical language (ie using unisons), then the benefit of the simple interaction was revealed and thus the whole system worked more effectively. Perhaps then this notion of balance is about balancing the triangle of variables: the musical characteristics of the live input, the complexity of the processing controlled and the way that the control happens.

5.4 Contributions to knowledge

This thesis presents works from an intensive four-year period dedicated to exploring interactivity and relationships in performance. I have helped to create twelve new pieces for piano and live electronics and explored collaborative notation with specific solutions offered for certain types of control. I have helped to create and verify several new 'performance environments', giving composers feedback on their success and offering suggestions of refinement. I have broken into new territory with electromyography and motion tracking technology, using these in conjunction with piano playing and have offered some detailed insight into the physical sensations of interactivity from a performer's perspective. Finally, I have created a prototype piano challenging the existing design of the instrument to benefit the use of extended techniques and live electronics.

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