Commentary on the Portfolio of Compositions

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Composition Portfolio Contents

Total: 98′

Contents of Accompanying CDs

This portfolio is accompanied by 2 audio CDs.

Haute Rorschach and *When all memory is gone* contain important low frequencies and needs to be listened at over loudspeakers that specify Frequency response as 40 Hz -22 kHz, are ideal.

Mutation 2 needs to be played through external loudspeakers – the main compositional intention will not come across via headphones.

The audio outcomes may be quite diverse as many of the pieces (*Haute Rorschach, When all memory is gone, Drift, Gala* and *Mutation 2*) have certain aspects left open to interpretation.

CD 1: Audio Recordings

Track No.

1. *String Quartet No 1 - KO*
   Kate Ellis (Cello), Joanne Quigley (Violin), Paul O'Hanlon (Violin) , Lisa Dowdall (Viola).

2. *Fata Morgana – Loss*
   Michelle O'Rourke (Voice), Cobi van Tonder (Computer: Ableton Live).

3. *Fata Morgana – Arrest 3*
   Michelle O'Rourke (Voice), Cobi van Tonder (Computer: Ableton Live).

CD 2: Audio Recordings

Track No.

1. *Haute Rorschach*
   Cobi van Tonder (Max/MSP Micro Tuner patch routed to 6 individual Ableton Live Virtual Instruments created with the Ableton Tension physical modeling string synthesizer, Tape Part: Glitch and Reverb).

2. *When all memory is gone*
   Cobi van Tonder (Max/MSP Micro Tuner patch routed to 6 individual Ableton Live Virtual Instruments created with the Ableton Tension physical modeling string synthesizer, the native Ableton Reverb is also used dynamically as major spatial sound element).

3. *Drift*
   Elise Mac (Norwegian Hardingfele, Violin), Cobi van Tonder (Computer: Ableton Live for layering and Tape Delay processing).

4. *Gala*
   Elise Mac (Norwegian Hardingfele, Violin), André van Rensburg (Shakuhachi, Guitar), Cobi van Tonder (Computer: Ableton Live for layering and Tape Delay processing).

5. *Mutation 2*
   Cobi van Tonder (Cycling74 Max/MSP Markov chains (transition probabilities) mapped to Nord Rack 2x Synthesizer, Max/MSP Micro Tuner Patch mapped to sine tone generators of Nord Rack 2x Synthesizer. Mixed in Abletone Live).

Abstract

The portfolio contains seven compositions with varying instrumentation, ranging from string quartet to computer processed voice ensemble to purely electronic forces. *Fata Morgana* is the largest work in the portfolio and written for female voice ensemble, percussion and live computer processing or tape. Its main concern is that of extending the human voice via the auditory illusion of the Shepard's tone. *String Quartet No 1* contains excessive glissade to expose microtonal qualities. *Haute Rorschach, When all memory is gone, Drift, Gala and Mutation 2* all explore complex and unique microtonal tuning systems and are written with instrumentation left relatively open ended: given certain conditions, both acoustic and electronic forces are able to perform it.

The most prominent compositional aspect that features in the portfolio is an approach towards the experience of movement in terms of colour, form, texture and space. Material consists of lines and curves such as glissandi or the Shepard's tone auditory illusion, pitch fields, waves, pulses, flickering morphologies, distorted glows, morphs and slow transformations. This material originates from focusing on the internal properties of sounds, for example, the use of microtonal intervals that are clustered to produce beating patterns, third tones and unique colors. Macro forms are determined by this material and range from drone to simplistic, repetitive gestures. The final approach is a focus on the experience of sound in and as space: most pieces feature artificial acoustics as prominent part of the material and overall texture.

Acknowledgments

Foremost, I would like to thank my supervisors, Evangelia Rigaki and Donnacha Dennehy for their support, encouragement, guidance and direction. Thank you also to Matthew Causey and the Digital Arts and Humanities program and the Department of Music for their support and guidance.

Thank you to the many wonderful musicians, artists, scientists, lecturers, fellow students and friends, literally all over the globe, with whom I have been incredibly lucky to meet and share ideas. Some I have known for a very long time and some I have met during the past 4 years. Thank you Kevin Volans for many lessons and memorable conversations. Sincere thanks to Kate Ellis, Joanne Quigley, Paul O'Hanlon, Lisa Dowdall, Michelle O'Rourke, André van Rensburg and Elise Mac who performed and/or recorded my pieces with open attitudes to try out new ideas.

Lastly, special thanks to my family for their immense love and support over the years.

Dedicated to Andrea and Dario.

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Note to the reader:

The research presented in this thesis is two-part: the portfolio in the format of scores and audio recordings function as main practice based research. The written commentary takes on the form of a reflective, introspective analysis of prominent aesthetical concerns and characteristics, as they feature in the portfolio. This document is structured as a creative arts practice journal. Historical and theoretical questions, while considered as influences are not presented within a formal theoretical discourse as one would expect in work of musicology. Instead the complete focus is dedicated to the motives, character, aesthetics and territory of the compositions.

Introduction

One of the most prominent influences in the way I think about sound and music goes back to memories of the natural land- and soundscapes of my youth. Holidays spent on the tropical Natal coast line in South Africa, hikes in the Drakensberg mountains, the flat open starry night skies of the Karoo desert and the heavenly peace of my brother's farm in Eastern Transvaal – a place without electricity, phone lines, traffic, machines; where daily activities included chopping wood for the coal stove fire that also heated up the geyser for hot water… A small wooden house situated on the highest rocky hill in the area. At night one could only see two other lights far in the distance from two other farmhouses in the area. I spent merely a few months living there, but it was by far the most heavenly and tranquil time of my life. The soundscape was meticulously detailed because of the lack of noise. One could hear insects, birdwings, voices of school kids walking home and women singing from a great distance. Because of the beautiful natural acoustics (many reflections from natural surfaces including rocky cliffs behind the hut) the place was truly sonically 'alive' and dynamic. Each sound, each action, each footstep, each spoken word had a kind of acoustic halo around it with a delicate spatial prominence. This effect was perhaps emphasized also due the huge amount of solitary hours I spent there. It felt like light, sun, visual, sound, thought, existence all morphed into a singular tangible consciousness where boundaries between exterior and interior dissolved: a kind of nirvana.

On a windy day, the most complex surround sound patterns would emerge from the wind dancing through patches of long grass. Like some immense invisible dancer moving in many places at the same time.

Later, whilst studying music at WITS University in Johannesburg in 2005, I met Kevin Volans and heard him and Gill Richards perform *Cicada*[1] for two pianos. Up to this point my interests were purely in field recordings, electronic ambient and dance music and I was also a producer of commercial soundtracks for television, radio, mobile media and sometimes theatre. This concert was a point-of-no-return. I was mesmerized by the complex beauty and mystery of what I heard: it felt like the piece had some kind of consciousness of its own, something very similar to my memories of the farm. It was something that wasn't there in the notes, in the interlocking patterns, but rather an image that appeared because of the patterns.

What I am describing is a kind of 'negative space' – a complex pattern that exists, made up of all the interrelationships between notes and sound parameters that, so to speak, bring a piece of music 'to life'. Of course this idea overlaps heavily with the fields of psychoacoustics and auditory perception; I will not aim to occupy this vast space. Instead, my investigation within this portfolio is focused on the structural relationships between material and overall form, from a compositional point of view. This can be the relationship between material and its development, be it gradually over time as process form, or alternatively in the way that microscopic (microsound or microtonal/spectral) elements of sound determine the macro structure[2]. The material being most important, it needs to possess some undeniable inherent beauty in order to 'seduce the listener'[3] into a liberation of the senses. Form comes into play when sustaining this material further to change the listener's perception of time.

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[1] Volans, *Cicada,* compact disc.

[2] For example the practice in Spectral Music where a spectral analysis of a specific note played on a specific instrument at a specific volume, attack, sustain and decay displays the prominent overtone frequencies of the sound, and these frequencies are then written into the piece. This is a good example of how a microscopic element of sound is observed and then used structurally.

[3] Kevin Volans, Composition Lecture of March 2012.

Another way to ask the same question, from a different perspective, is to ask what is the key *intrigue* or mystery locked up in the material and how best to *disguise* and *reveal* it over time. In this regard, certain minimalist aesthetics as found in Japanese Zen Garden design, or works by composers such as Morton Feldman, James Tenney, John Chowning, Kevin Volans, Éliane Radigue, Maryanne Amacher and William Bassinski successfully achieve this goal, be it via different means. For Volans key elements to successful modification of the perception of time is to use 'supremely seductive/enchanting material', long durations, or by bringing back material in unexpected places or combinations.[4] Feldman approaches his music as 'time canvases' in which he 'more or less primes the canvas with an overall hue of the music.'[5] Tenney vertically fluffs open spectral colors of the harmonic overtone series like a peacock opening its tail, in slow motion. Chowning creates a musical entity that displays high levels of self-similarity across scale and parameters. Radigue shape shifts musical material in even more extreme slow motion and such fine increments that the listener is fooled as to how A transformed into B. Amacher literally distorts the senses (ears) and shifts or vibrates between external spatial acoustics and internal 'ear-born sound.'[6] Basinski's underwater reverb sound and process of physical tape loop that literally disintegrates in *The Disintegration Loops* (2002–2003)[7] is an example of surface as object in music and process as form. Many drone musicians submerge the listener by sheer scale (duration and/or loudness) into a sublime state.

In Chapter One (Review of Work) these composers and exemplary works are examined in terms of exactly these questions stated above. Their inherent minimalist aesthetics, material, form, texture and spatial elements are carefully

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[4] Kevin Volans (personal communication, April 7, 2016).
[5] Morton Feldman, *Give My Regards to Eigth Street - Collected Writings of Morton Feldman*, B.H. Friedman (ed.), (Cambridge: Exact Change, 2000), 88.
[6] Eliot Handelman, 'Maryanne Amacher - Ears as Instruments: Minds Making Shapes' (https://web.archive.org/web/20120825215513/http://www.colba.net/~eliot/amacher.htm, 3 March 2016).
[7] Basinski, *The Disintegration Loops*, compact disc.

examined. Simultaneously I continuously highlight how each of these aspects relate to my own compositional thoughts and the pieces in this portfolio. Commentaries on my portfolio compositions are then presented in the succeeding chapters, with a conclusion reflecting on my motivations for composing and considering possibilities for future work.

Because such a high percentage of the sounds that feature in my portfolio are electronic or processed, a lot of emphasis is placed on thoughts regarding how to describe and manipulate the inherent qualities of sounds. From the beginning it will be clear that cross-pollination between acoustic and electronic compositional thinking is prominent. In this regard theories found in acoustics, synthesis, the physics of sound and sound art are presented. Curtis Road's *Microsound,*[8] Trevor Wishart's *On Sonic Art*[9] and Joanna Demers' *Listening Through The Noise, The Aesthetics Of Experimental Electronic Music*[10] are of particular influence to this commentary.

Lastly, I would like to highlight one important fact: it is not my purpose here to justify one school of thought or one genre/style/movement or even a single composer at the expense of another. As a composer and listener, I am inherently drawn to certain forms and aesthetical qualities of certain composers' works and I use these to contextualize my creations. That does not mean I do not deeply value and respect the work of composers who are not mentioned or who are mentioned in opposition to an aesthetic element in order to illustrate a point.

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[8] Curtis Roads, *Microsound*, (Cambridge, Massachusetts: The MIT Press, 2001).
[9] Trevor Wishart, *On Sonic Art*, Simon Emmerson (ed.), A new and revised edition, vol. 12, Contemporary Music Studies (Harwood Academic Publishers, 1996).
[10] Joanna Demers, *Listening through the Noise, the Aesthetics of Experimental Electronic Music* (Oxford University Press, Inc., 2010).

Chapter One: Review of Work

1.1 The influence of Abstract Expressionist Painting

> Cicada is my first genuinely minimalist piece. The title comes from a series of works by Jasper Johns, that are built up from hatch-marks and which are mirrored symmetrically down the middle of the paintings. I felt the pictures reflected the way in which the two piano parts mirror and interlock with each other exactly. But the real inspiration for the piece was the work of James Turrell. A friend took me to an opening of his in Kilkenny. In the evening we sat in large cubic light box in the grounds of the castle and over a period of an hour watched a square of sky overhead turn from the blue-gray of Irish clouds, though Yves Klein blue to slate black. I stayed overnight in my friend's minimalist house in Kilkenny. The next morning I woke to a glittering square of sunlight reflected off the sea and I decided: no composition; don't change anything except the tone.[11]

There is something completely ecstatic about each pattern that is repeated a number of times and then simply switches to the next pattern in Volans' *Cicada* (1994). The only development is indeed that of the tone and expression. What strikes me, as the most obvious parameter, is the way the rather delicate pauses between notes change. Three kinds of pauses: between the notes, to create the rhythm; between repetitions of the same pattern, and between one pattern to the next. Every single length of each minute silence or pause, seems to vary. Within these pauses grows the negative space, or in my opinion, the *true image of the*

[11] From the program notes written by Kevin Volans for *Cicada.* Kevin Volans, 'Cicada Program Notes' (http://www.musicsalesclassical.com/composer/work/1651/11915, 12 March 2016).

whole. As if one listens *through* the patterns *to* the music. This is possible because there is no transitional material to clutter the listener's memory. The individual patterns are short memorable fragments and what connects one pattern to the next is the high amount of overall self-similarity of the musical material – one could call them permutations of each other. This enables the listener to stay in one state with the composer and so the original intension of the piece succeeds.

The macro structure bears a striking resemblance to way the Jasper Johns hatch-marks are positioned on the canvas. Similar modules varied in subtle ways create continuity. This makes for a bombardment of pattern and color, forcing the eye to dance over the canvas (or the ear over the time-canvas). It reminds me of Morton Feldman saying that he prefers to work in modules rather than in a linear continuity: 'I don't work in a continuity, I work module-ly',[12] which brings me to the first major overall influence: minimalism or in some cases minimal material.

Minimalism is a problematic term as it is widely used in diverse contexts. Since it is not in my interest to wear the hat of a musicologist and try clarify this term, I will only describe the specific composers who influenced me and who also refer to minimalist (mostly Abstract Expressionist) painters as inspiration to specific works or compositional attitudes. *Cicada* is a clear example of a composer inspired by an abstract expressionist painter, the following series of attempts to describe Morton Feldman are also examples of this notion:

> Feldman approached his sounds the way that he felt painters approached their paints: as objects capable of assuming shapes and forms but not as conveyers of narrative, metaphor, or origin. Throughout his career, Feldman made statements to this effect: 'leave the sounds alone; don't push them' (quoted in Villars 2006, 28); 'Most music is metaphor…. I am not metaphor' (quoted in Villars 2006, 35-36); […] 'Everything is a found object. Even

[12] Feldman, *Give My Regards to Eigth Street*, 181.

> something that I invent is a found object. . . . And in realizing that, you must lose your vested interest in ideas' (quoted in Villars 2006, 195). Simply put, Feldman was a sound materialist, relishing the internal characteristics of sounds rather than their semantic potential.[13]

For me there is actually no differentiation between thinking about sound and thinking of visual forms, shapes, colors – it is all very abstract but my musical imagination is a blur of visual, sound, tactile, emotional, sensory and cognitive thought. Neuroscientist Daniel J. Levitin wrote a book called *This is Your Brain on Music - The Science of a Human Obsession* in which he describes sound in a refreshing way: 'Sound is a mental image created by the brain in response to vibrating molecules.'[14] Just because our brains divide external reality through our senses as sound, smell, touch, vision and taste does not mean reality really works like that. We are limited to our senses as interface to the external world but intuitively we can sense that there is more going on. This is also why auditory and visual illusions make such interesting subject matter.[15] They *distort* our normal ways of hearing and seeing and expose the flaws that exist in our perceptual systems.

In my opinion, if art has a function, it is to distort our normal view of reality and even morality. There is a great similarity between this type of distortion and the ways in which dreams contain sometimes-impossible combinations of imagery or actions. On careful analysis and pondering, usually the *errors* or impossible scenarios are important clues to subconscious needs, desires and even pointers to the solutions of practical problems. Even within the creative act, within the process of making something, everything worthwhile I ever created has been by

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[13] Demers, *Listening through the Noise,* 80.
[14] Daniel Levitin, *This Is Your Brain on Music: The Science of a Human Obsession* (Plume/Penguin, 2007), 22.
[15] Both auditory and visual illusions are discussed in Chapter Three.

means of lucky mistakes, something unintentional that happens and I realise that it sounds good.

Abstract expressionist painting succeeds in the process of *distorting* the senses in powerful ways. Rothko compared the painter to a philosopher and said that similar to philosophy, the work of art is the creation of a particular notion of reality. He continued to call painting 'plastic speech' through the use of colours and forms. At a mature point in his life and work, he considered that plastic languages only serve art when they generalize beyond the particular. That the artist needs to reduce phenomena in order to shed light on human sensuality. He came to the conclusion that sensuality is neither objective experience nor subjective experience but something which exists outside of both and therefore contains both.[16] [17]

I understand this 'generalization beyond the particular' to imply avoidance of narrative, metaphor or origin, in other words: abstraction. What Rothko meant by 'reduction of phenomena'[18] is the use of minimal material. One way of achieving abstraction is via focus on the surface.

So what then is the surface of music? There are many possibilities: it can be structural, a process made audible: movement of waves so slow and large that it is impossible to experience the cause but only the effect (or ripples at the end of the waves). Or a fragment looping and shifting over time that points to a larger (hidden) structure or mechanism. It can be smallest perceivable micro grains that make up sounds. It can be the literal surface sounds of instruments exposed to human gesture, for example extended techniques at extreme soft levels in the music of Lachenmann. In electronic music it can imply the surface of the sound

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[16] Rothko's son, Christopher Rothko edited and published his father's unfinished book in 2004.
[17] Mark Rothko, *The Artist's Reality: Philosophies of Art* (New Haven, Conn: Yale University Press, 2006), Kindle edition, 'Particularization and Generalization'.
[18] *Ibid.*

producing technology used such as scratched records, tape mechanisms, glitches, loudspeaker noise floors. Surface can be exposed via digital processes such as spectral analysis so that hidden components of sounds are magnified into perceivable time domains. It can be colour. It can be texture. It is also prominent in the process of hearing itself, in becoming aware of how sounds interact with the eardrum to create spatial awareness or generate in-ear tones.

Kevin Volans articulates surface as *detail*: 'Detail articulates surface and thereby articulates form. Without detail or surface is there form? A single detail that transforms the whole, like a dot of red in a Poussin painting.'[19]

For Feldman it meant 'relishing the internal characteristics of sounds rather than their semantic potential'.[20] Focusing in on the internal characteristics of sounds is one of the main elements that can be traced throughout each chapter in this commentary.

The highly articulated and psychological use of colour in colour field painting (a sub category of Abstract Expressionism) have a lot in common with how the *internal characteristics of sounds* are used in the context of spectral music. For example, a single note, played at a specific volume, with a specific attack, sustain and decay: these are all elements that have an effect on the timbre (which can be scientifically observed via spectral analysis and creatively used in various applications of spectral music and synthesis). Elements that are perceived and described by composers as timbre or colour. These are vertical ideas about harmonic spectra as material that is a major topic of microtonal music, spectral music and ideas around timbre.[21]

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[19] Kevin Volans, *Art Begins Where Craftsmanship Ends* (2016).
[20] Demers, *Listening through the Noise,* 80.
[21] To be addressed in sections 1.5 to 1.8.

In thinking about abstraction another aspect is very important to me: the artist's 'notion of reality*':*

> The subject of a painting is the painting itself, which is a corporeal manifestation of the artist's notion of reality, made manifest through the production on the canvas of objects, or qualities, or both, recognizable or created, which are referable to our experience, either directly or though reasoning.[22]

If I take this to a very personal position, I would say that the subject of composition is composition, which in turn (in this case) is a corporeal manifestation of *my notion of reality.* To be honest, reality for *me* is a very thin layer or curtain that surrounds us and I would like to find a way to see what is behind it. But somehow it does not work to think about it. All thoughts vanish and there I am, in a little boat on the sea. Overwhelmed by the strong desire to just surrender to the waves, stormy, calm, mesmerizing, ebb and flow, light shimmering on wonderful blue waves.

The sea is the best example of perfect form: it is forever. Its ebb and flow rings out on every coastline on this planet. It is endless variation embedded in endless repetition (with no two ebbs and flows ever sounding the same). It reveals surface, yet it stirs in great dark depths. It has mood swings and patterns within patterns. In a way it bares maximal similarity to Morton Feldman's description of 'stasis' and it is *huge.*

Upon returning to my studio, my computer, 'this reality', I am overwhelmed by the desire to produce waves. To try out endless variations of combination tones, patterns, structures and listen to how they move through space… I want to keep it simple and stick to waves: 2 tones at a time. Microscopic shifts. Perhaps add some voices. Within these few items I already have my life's work mapped out.

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[22] Rothko, *The Artist's Reality: Philosophies of Art*, 'Subject and Subject Matter'.

When it comes to music or sound patterns or textures or colours, I am intuitively drawn to certain sounds/patterns and intuitively repelled by others. This attraction/repulsion functions on a deeply intuitive level, as if the roots are situated in my subconscious mind in the same place from which nightly dreams originate. When I reach a state of 'flow' during my working process, I always vividly remember my dreams from the previous night. This is usually a clue that something is right. The moment I think too hard it vanishes. The muse leaves.

Rothko said one more thing that I would like to highlight: plasticity is the way an artist creates 'the effects of movement in space, a sensation or experience of reality as something which moves through time and space.' That 'without color, form, and space', we cannot perceive the 'sensation of movement' or the 'artist's reality'. And that if we do perceive this, then we are becoming aware of the painting as something, which has a *life.* The painting is the premise for a journey that we follow and take, or, as he says a little later, the picture is a vehicle for an experience that lives outside the picture. That experience, he says, is the 'experience of plastic continuity.'[23]

Feldman, Rothko's friend, calls his compositions 'time canvases' and describes the subject of his music as 'surface'. He says that he 'more or less primes the music with an overall hue of the music'. He also makes an important statement about composition:

> I have learned that the more one composes or constructs – the more one prevents Time Undisturbed from becoming the controlling metaphor of the music.[24]

Feldman's term 'Time Undisturbed' points to a major difference between the music of Feldman and Volans for example versus that of Louis Andriessen *De Staat*

[23] Rothko, *The Artist's Reality: Philosophies of Art*, 'Plasticity'.
[24] Feldman, *Give My Regards to Eigth Street*, 88.

(1972-76)[25] or Steve Reich *Music for 18 Musicians* (1978)[26]. It is in the material itself as well as the process that is revealed over time. With the latter two composers, a definite sense of forward motion due to the linear rhythmic patterns can be heard. The inherently linear material usually varies by some process of shifting, adding, subtracting, being situated in new surrounding (i.e. material surrounded by different layers of counter material). Incessant, driving and constantly presenting minimal surprise elements; this material presents an exhilarating journey. In this context, however, there is a mechanism of expectation in the memory of the listener and a sense of direction.[27]

With Feldman and Volans, the music really just hangs there in an endless/timeless kind of fashion, as if you've been plunged into a gravitationally abnormal space with unknown density. With *Haute Rorschach* I try to achieve this by keeping fragments deliberately ambiguous and short with large expanding and shrinking 'spaces' in between. These spaces are not silences, but instead pierced with distorted glitch and noise fragments that serve to emphasize space. The noise fragments are treated with large reverb and mixing techniques so as to create an artificial acoustic space that emphasizes scale. In contrast, the musical fragments sound close and dry and consist mostly of staccato or short notes. The intervals are also made up from microtonal scales, so that many fragments ripple out in extremely small intervals, shrinking the scale of this material to be even smaller, in turn allowing the large glitch space to seem even bigger through contrast. By having these gaps the musical flow is interrupted and I feel this accentuates the vertical properties, which in turn creates a timeless/floating feeling.

Feldman describes that he likes to keep 'that tension that is stasis' by moving not only forward but instead 'back and forth'. In *Haute Rorschach* I attempted to do

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[25] Andriessen, *De Staat,* compact disc.
[26] Reich, *Music for 18 Musicians,* compact disc.
[27] It is after all termed 'Process Form'.

this quite literally: fragments literally mirror each other or reverse with the previously described spaces in between.

> And so I'm involved like a painter, involved with gradations within the chromatic world. And the reason I do this is to have the ear make those trips. Back and forth, and it gets more and more saturated. But I work very much like a painter insofar as I'm watching the phenomena and I'm thickening and I'm thinning and I'm working in that way and just watching what it needs. […] But it's like Rothko, just a question of keeping that tension or that stasis. You find it in Matisse, the whole idea of stasis. That's the word. I'm involved in stasis. It's frozen at the same time it's vibrating.[28]

A piece like *Saxony* (1978)[29] by James Tenney also has a similar *vertical* quality, perhaps because of its harmonic structure or spectral vertical logarithmic overtone material as main sense of movement. Even though this material builds up in an additive manner as time progresses, the strong vertical upward (in pitch) motion in the progression cancels the feeling of linear time. One is in fact listening to a single note (and it's overtones) and thus one could almost compare it to listening to one instance of a sound through a microscope – zooming in on a frozen moment in time and observing all the microscopic details outside the temporal dimension. So it literally becomes a *frozen* moment revealed in a different time dimension. Some other spectral composers reintroduce linear drama, tension and narrative to this type of material, but I prefer the Tenney approach to keep the macro form extremely simple and transparent. In the case of *Saxony* a single diagonal line.

Saxony and various other spectral Tenney pieces like *Spectral CANON for CONLON Nancarrow* (1974)[30] have provided a solution for me whilst stuck on how to approach the microtonal material in *Drift* and *Gala.* Initially I was trying out many possible chord progressions. After eliminating notes from my 5-tet, 21-tet, 34-tet

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[28] Feldman, *Give My Regards to Eigth Street*, 183-4.
[29] Tenney, *Saxony,* compact disc.
[30] Tenney, *Spectral CANON for CONLON Nancarrow,* compact disc.

and a G fundamental overtone series, which were all stacked on top of each other, until only a rainbow of 34 pitches were left, I spent a few days listening to possible combinations and choosing a basic 'chord' progression. The result was interesting but complex and slow to listen through in an oppressive kind of way – I felt intrigued but tortured! Intuitively I knew the problem was that the *magic* was in the unique vertical proportions but I was stuck not knowing how to expose it. More than any other spectral composer, Tenney opened my ears and mind to how extremely effective simple vertical movement can be when the aim is to expose the strangely beautiful complex microtonal set of proportions.

The result will be described in more detail in Chapter Six, but the bottom line is I found a way to vertically structure time in a way that has depth and lightness to it.

1.2 Like a Japanese Zen Garden

Dr. Gert J. van Tonder who has done extensive research in visual perception with focus on Japanese Zen Gardens influences my view of minimalism. He has explained in simple terms how important it is in dry rock gardens that two thirds of the rocks are actually buried underground and completely hidden from sight. This is an important principle in Japanese Zen Gardens: what is revealed is only part of a much larger composition. There is a hidden depth: lines extend underground or into the surrounding landscape. His research has also revealed how important the 'negative space' or empty space in between the rock formations is: as if what is carefully positioned and visible to the eye primarily functions to subconsciously make the observer experience what is *not* there…[31]

[31] Gert J. Van Tonder, Michael J. Lyons and Yoshimichi Ejima, 'Perception Psychology: Visual Structure of a Japanese Zen Garden,' *Nature* 419/6905 (2002): 359-60.

This has become a very important motto for me in my own work, that a great deal of what goes into a piece is not revealed, but that I 'crop' the image in the end to reveal only a 'framed' part of the whole.

There is some resemblance here to Morton Feldman retelling what Philip Guston said to him about a Rothko painting (that influenced Feldman's compositional approach):

> That's when he said to me, "Is it there?... How much of it is there?" Not if it's all there, but how much has to be there for it to be there? And that's very very important. [32]

My interpretation is very much influenced by this, but my focus rests on the following idea: that only a part of the whole is revealed, be it surface details or a structural branch.

In this portfolio it can mostly be seen in the microtonal pieces that exist in complex vertical harmonic systems, for example 6 alternative temperaments (3-tet, 5-tet, 8-tet, 13-tet, 21-tet and 34-tet equal temperament) layered on top of one another in *Haute Rorschach* with a rather subtle dissonant/harmonic result that is completely unique and gigantic in the vertical intervallic potential and resulting beat patterns. Yet, only fragments of the possibilities are chosen as material but these strange moments could not be possible without the whole. In each microtonal piece different scales are combined to create unique intervallic possibilities.

[32] Feldman, *Give My Regards to Eigth Street*, 178.

1.3. Minimal 'surface' objects in Electronic Music

Electronic music really lends itself to the manipulation of surface detail in sound, more than any other musical force. The fact that one can record or generate material outside of time – work like a sculptor or film editor, to zoom in, slow down, splice, recombine, spatialize and to do so at any desired timescale makes for incredible control of detail. Effects such as filters and reverb are particular tools in the manipulation of perceived space, surface, texture and colour.

To better clarify minimalism in electronic music contexts, Joanna Demers in *Listening Through the Noise*, *The Aesthetics of Experimental Electronic Music,* offers a refreshing new set of categories for contextualizing electronic music: *Sign* (with reference to Electroacoustic Music and Electronica)*, Object* (with reference to Microsound, Drone Music, Dub Techno, and Noise) and *Situation* (with reference to Site in Ambient, Soundscape, Field Recordings, Genre, Experimentalism and the Musical Frame).[33]

Her ideas around *Object* are of particular influence here. Demers finds similarities between the desire for 'objecthood' of minimalist visual artists of the 1960's and *the* 'supposedly expressionless' minimal objects in Microsound under the phrase 'Minimal Objects in Microsound.' This bares resemblance to Schaeffer's 'ideal listening' where the listener focuses on the *sound as itself* or as an abstracted object instead of any connotation to the source and meaning that the source might imply.[34] She also points out how some practitioners in this field insist on *ideal listening,* whilst others reject this notion to allow other forms of listening. Next she points out how the introduction of repetitive beats as backdrop function as a means of abstraction, since the listener accepts the sounds as music and listen

[33] Demers, *Listening through the Noise*.
[34] *Ibid,* 70-72.

again to sounds as abstract objects instead of connecting these sounds to semantic meanings.

*Analogique B (*1959)[35] made via granular synthesis by Xenakis and *Concret PH* (1958)[36] in which a recording of burning wood is granularly modified are regarded as the first microsound pieces. 'Micro' because the granular sound 'grains' have durations of ranging between one-thousandth and one-tenth of a second. Xenakis also worked with ataxy or degree of order versus disorder within the granular context, controlling the flow of ataxy via a matrix of probabilities.[37] Working at such a microscopic level is by default abstract – being zoomed in so far, the working process is destined to produce unusual sounds and structures. I have experimented with granular effects as well as using sound at extreme short durations and manipulating them via probability objects in Max/MSP.[38] This can be heard in *Mutation 2* as a grainy cloud like texture that fades in as textural element of contrast to the rest of the material.

Glitch music is a further branch of microsound influential to this portfolio. According to Kim Cascone, the way it happened was that DJs 'unearthed' the history of electronic music via thrift store digs, discovering and being influenced by

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[35] Xenakis, *Analogique A et B,* compact disc.
[36] Xenakis, *Concret PH,* vinyl.
[37] 'Analogique B was designed by scattering grains onto time-grids, called screens by Xenakis. The screens represented elementary sonic quanta in three dimensions: difference thresholds in frequency, amplitude, and time. He coined the term ``grains of sound'' (Xenakis 1960), and was the first musician to explicate a compositional theory for sound grains. […] His next theoretical elaboration scrutinized the ataxy or degree of order versus disorder in a succession of screens. Maximum disorder, for example, would correspond to extreme changes in the distribution of frequency and amplitude energy, creating a sonic effect akin to white noise. Perfect order would correspond to a solitary sine wave extending across multiple screens. The flow of ataxy could be regulated via a matrix of transition probabilities, otherwise known as a Markov chain',
Roads, *Microsound*, 75-77.
[38] Max/MSP is a graphical object oriented programming language developed for art and music and created by a company called Cycling74 (https://cycling74.com, 2 January 2016).

the work of Karlheinz Stockhausen, Morton Subotnick, and John Cage, 'and their influence helped spawn the glitch movement'. Cascone wrote an influential article called *The Aesthetics of Failure: 'Post-Digital' Tendencies in Contemporary Computer Music* in which he describes glitch as music that: "exploits the precariousness of the digital signal and celebrates the sonic effects of digital glitches, bugs and errors".[39]

I can attest to a deep respect for many of these musicians. German *Mille Plateaux* label with albums like *Clicks_+_Cuts*[40], Mika Vainio (Pan Sonic), Oval, Ryoji Ikeda, Carsten Nicolai are important examples. What draws me to this music, more than any conceptual layer, is the extreme sound qualities and extreme range of sounds that can be found in this scene. The sounds of glitch were truly new when they first appeared and I imagine Luigi Russolo would have been proud. Ranging from literally the sound of machines crashing and failing, to physical scratches on vinyl, to breaking or bending electronic technology, to the sounds of open electricity, to the microscopic worlds of sound that exists in the softest bottom layers of recordings, when one amplifies it to extreme proportions to hear the crackling insect shimmering dust. Also including the use of pure code to splice audio at a non-zero crossings and making loud digital clipping noises the main material, or the converting of audio files to wrong bit rates that result in harsh digital distortions. Ranging from extremely loud and busy to extremely soft and empty.

These sounds, once again has a strong focus on surface detail and texture. But it is not only the sounds, it is what they lend themselves to: to ring out the acoustics of gigantic virtual spaces. They create beautiful reverb 'tails' and clouds. In this case 'space' is interestingly enough in my opinion the main element or secret ingredient. It is quite literally the negative (acoustic) space – and has texture. The harsher and louder and noisier the glitch, the more of this space gets revealed.

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[39] Kim Cascone, 'The Aesthetics of Failure: "Post-Digital" Tendencies in Contemporary Computer Music,' *Computer Music Journal* 24/4 (2000): 12-18.
[40] *Clicks_+_Cuts,* compact disc.

Reverb in itself being a powerful tool in electronic music: it can be used in varying degrees of subtlety. 'Reverberation, in psychoacoustics and acoustics, is the persistence of sound after a sound is produced'[41] A reverberation, or reverb, is the reflections of a sound against the surfaces of a space. Naturally reverberations may be reflected and next the reflection of the reflection gets reflected at a weaker level, and so on, until the sound is absorbed by the surfaces of a space. The duration for the sound to die is referred to as the reverb time. This can be extraordinary long in places like silos or tunnels. When manipulated artificially it becomes another parameter in the composer's palette and can take on exciting extremes. It becomes a feedback mechanism, meaning it has the potential to keep growing or swelling and at the same time, it has beautiful liquid qualities that can be further developed via filters and equalization.

Mika Vainio's 1996 mix of Bjork's *Headphones*[42] which is extremely sparse, deep, large and empty illustrates how filters can be set up with specific frequency bands allowing the composer to completely cut, boost or subtly highlight specific colours in the frequency spectrum and even sweep over frequencies like a spotlight can sweep over a stage to highlight certain objects. The voice comes in at 1"50', only lasts for about 50 seconds and is heavily equalised to be rather thin, dry, tinny and close as if heard over a telephone. The sample is degraded to sound like a low bitrate sound. It also just ends abruptly and returns to a minimal piano riff. Each sound layer is exquisitely treated and differentiated in the mix. The bass is round and like velvet but with a higher frequency click to make it cut through the mix. The piano sounds like it has some kind of chorus effect and is also filtered. A few other peripheral sound textures hover around but a vast amount of spectral space is left empty and open only for softer reflections to cross interfere with each other in this space.

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[41] Michael Valente, Holly Hosford-Dunn and Ross J. Roeser, *Audiology*, (Thieme, 2008), 425–426.
[42] Björk, *Headphones,* Mika Vainio (remix), compact disc.

Then there are also the subtle surface noises that function as added layers of coloured *silence*. The crackles of a gramophone player or some subtle presence in the mix, for example in *The Caretaker* (James Kirby's music). The Caretaker's tracks usually consist of loops of melancholy piano always set against some foreground noise that sounds like either a vintage tape player, or record or some form of technology that adds different qualities of dirt to the mix. [43] With this single layer, we are transported to the past.

Or the sounds of physical decay in William Basinski's *The Disintegration Loops* (2002–2003) and the trope it has become: according to Basinski he was attempting to transfer previous recordings from magnetic tape to digital format. It was too late though, as the ferrite detached from the plastic backing of the tape and literally 'disintegrated' whilst being recorded. In other words he kept playing them till they completely died and was able to record the whole process.[44] Bassinski further added a spatializing reverb effect. The piece gained critical attention especially in the light that it coincided with the 9/11 World Trade Center attacks (chance has it that Bassinski and his friends were watching it happen from the roof of his building) and in an underground kind of way became the soundtrack to the grotesque historical event.

In *Haute Rorschach* small errors and artefacts found in the 'silence' between notes found in the recordings made of the instrumental string parts are amplified to the extreme. Next, they are spliced, pitch shifted, distorted or manipulated to create extreme noise bursts or dub/glitch like dirt as electronic counterpart material for the main 'clean' and harmonious plucked string melodic material. The noise bursts function to activate the artificial acoustics and emphasize the spatial elements and scale.

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[43] The Caretaker, *An Empty Bliss Beyond This World,* vinyl.
[44] This example of Basinski's music has elements both of surface objects and drone music, which will be discussed in the next section. Ultimately I would describe *The Disintegration Loops* as drone but many of these musical examples simply cross over between categories.

In *When all memory is gone* and *Arrest 3,* I use a reverb sample-and-hold function that feeds back on itself and keeps swelling in loudness. This signal is filtered and boosted to become rather dirty sounding, similar to *The Caretaker*'s surface noise. A second band-pass filter moves this sound to move forwards and backwards in the mix and fade according to hand-edited envelopes.

To sum up, via certain computer (or hardware) effects processing, various aspects of surface, color, texture and space can be carefully manipulated. This is effectively illustrated by various electronic music composers of minimal music as well as electronically produced drone music to be discussed in the next section.

1.4. Extreme duration, dynamic range and immersion in Drone music

The next iteration of *stasis* is created as the result of sound so long and large that it acts as a kind of listening sensory deprivation tank. In this scenario, the *sublime* is reached via sheer scale in terms of duration and immersion.

There are two prominent elements to drone: extreme duration and extreme loudness. Not all drone music exhibits both elements.

On the most extreme side of *loud* drone one can find pure noise music: Merzbow[45] using tsunamis of brutal noise. An attack on the whole body. Many noise musicians and noise music scenes such as Osaka in 1999 where I first experienced this kind of concert where concert goers are armored with earplugs or some form of ear protection and stand facing the musicians, 'listening' with concentration to the whole performance. The experience is definitely like going through a physical storm, as if leaning into heavy winds, trying to stay standing, your organs vibrating

[45] Merzbow, *Monmon,* compact disc.

with the sounds. Physical and tactile. At the end of such a performance, there's a kind of relief hanging in the air.

Éliane Radigue's work can be summed up as 'organic fluidity' and whilst sounding great at all volumes (I don't think loudness is her main concern), has its main focus *continuous change* over extreme duration. Her music[46] has a strange quality in an uncanny kind of way. It is like one sees something moving out of the corner of your eye, but whenever you turn your head to look, nothing is there. The riddle with her slow transformations is how you got from point A to point B. Change happens so slowly whilst the sound is so engaging that one suddenly realize one is in a different place, but unless you listen with absolute concentration, change just sneaks up on you.

Using mostly the ARP 2500, 'she could build sound from its constituent parts, changing in tiny increments up to 40 parameters such as frequency and modulation, encouraging waves to beat and pulse against each other. The music didn't contain sound: the sound contained the music.'[47] In this case I imagine this to be really as extreme, Radigue making tiny incremental changes one by one.

To illustrate her idea about time she said the following: 'I could change the sound from the inside. To explain it visually, you could imagine a mountain turning into a cup, but so slowly from one state to another; it takes time by nature.'[48]

This is no exaggeration. Returning to the Zen Garden principle, with each Radigue piece it feels like one hears the tip of the mountain of time. One is made aware that a large part of the structure lies there, larger than life and underground. I am a keen practitioner of the martial art of Tai Chi. In Tai Chi, the slower you move, the

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[46] Eliane Radigue, *Trilogie De La Mort*, compact disc.
[47] Pascal Wyse, 'Eliane Radigue's Brave New Worlds' (http://www.theguardian.com/music/2011/jun/16/eliane-radigue-electronic-music-interview, 1 April 2016).
[48] *Ibid.*

more you become aware of how much slower you can still move. The body becomes lighter and lighter – the sensation is first that of moving in liquid and then in air and then becoming air. In a way there is always a finer increment in which to move. It seems that this is the main goal that Radigue has as a composer. To transition in such fine increments that the illusion is that of a continuous *magical* transformation in which time itself becomes liquid.

Joanna Demers demonstrates how, what she refers to as *maximal objects in drone music, dub techno, and noise music,* with excessive durations and volumes all purport to transcend meaning, to push sound beyond 'semiosis to a state in which it communicates directly to listeners' bodies.'[49] In this regard there are actually many similarities to glitch and what was discussed about sound and space in the previous chapter.

Some people may find this kind of music extremely boring and some may even argue that it's not music, but for me it's an extremely powerful moment in musical experience. The loud volumes in some cases, extreme durations and lack of obvious changes have an immersive physicality that has textures like stormy winds attacking the body, or massive waves, tsunami even, or a dust storm blurring ones vision, or completely alien landscapes, massive buildings, hyper dimensional perspectives of other worlds, or sometimes less aggressive like the appearance of a rainbow in the sky or stepping into clouds of steam.

Certain aspects of the listening experience are exceptionally useful for the effect of immersion – for example all night or all weekend events at industrial warehouses and club spaces as venues, bunkers, churches – in these settings the music is part of the night, duration gets a different perspective, there is *time* to listen and *exist in*

[49] Demers, *Listening through the Noise,* 15.

the abstract sounds. Similar in some ways, I imagine, to experiencing *The Dream House* by La Mont Young[50].

A label such as *Touch* has a number of composers that I deeply admire such as Thomas Köner, Fennesz, Chris Watson, Lawrence English, Jana Winderen, Mika Vainio, Thomas Ankersmit, Oren Ambarchi, Phill Niblock, Hildur Gudnadottir and many more. Many of these composers are avid practitioners of making field recordings and using elements of these sounds. Materials include recordings of sustained pitches, tones or ambient material of long duration, multi-tracked to form a dense sound mass. Often the attack and decay of sounds are removed, via long fades and crossfades to achieve effects of seamless continuity. Sound is also usually presented in a minimum of four speaker systems to surround the listener.

Continuity and immersion are main intentions of my work, even when soft or when they have material completely different to drone. In these cases immersion is particularly achieved via the spatial components, usually by sending electronic sounds loudspeakers configured to surround the listening space. Configurations vary from 4, 8, 16 and even 43 speakers.

Spaces that are concerned with spatial qualities can be found around the world including Naut Humon's *Recombinant Media Labs* and *Cinechamber* surround theatres[51]. Bass shakers that respond to lower than audible bass frequencies are even built into a special floor to literally make the room shake and vibrate and extend the bottom range even further. Bass is an important factor when music depends on sounding 'large'. To reproduce large sound waves require special equipment and room space. Take a moment to consider the physical sizes of frequencies. Try to visualize a frequency traveling through the room as a sine wave with specific wavelength. How big is the A that the orchestra tunes to? How big is 65Hz (C-2) on a piano? How big is an octave below that?

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[50] Young and Zazeela, 'Dream House'.
[51] Humon, 'RML – Recombinant Media Labs'.

To calculate Frequency ***f*** to wavelength ***w***, you first need the speed of sound (which is influenced by the temperature).[52]

Then, a frequency of f = 440 cycles/sec (A)

Translates to w = c/f

= 343.4/440

= 0.78 m

for the wavelength.

Using the same calculations, you can find that 10KHz = 3.4cm, 1KHz = 34cm, 60Hz - 5.7m, 30Hz - 11m, 100Hz - 3.4m, 10Hz - 34.3m, 7Hz - 49m. At a 100Hz you already need 3.4 meters for just one wavelength to complete itself. Using bass shakers the lower bass frequencies morph into pure vibration. Thus, when talking about immersion, we are talking about something physical, truly engulfing the space and body.

At the extreme low range exist the infra sound performances of Scott Arford and Randy Yau in which their aim is to find the resonant frequencies of the concert venue and instead of listening to the music one feels and hears the building itself rattle and vibrate. Bass played over massive sound systems in massive spaces have an incredible effect capable of reaching the levels of a fighter jet ripping through the sky or thunder rumbling over a vast area of land; or tossing canon balls over a field or emulating the infrasonic vibrations felt during earth quakes. I am all in favor of exploiting the full dynamic range available in sound and whilst I am less interested in performances that exhaust the ear because of being too loud for too long, when used as punctuation marks here and there or as a layer and another parameter in the sound palette it is simply wonderful.

Another factor in drone is how the music shifts between periodicity and chaos. A clear sense of rhythmic 'pulse' is avoided, allowing pulsations to emerge as a result

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[52] At 20 degrees Celsius, the speed of sound is about c = 331.4 + 0.6*20 = 343.4 m/s. I used the calculator at (http://hyperphysics.phy-astr.gsu.edu/hbase/sound/souspe.html, 16 November 2015).

of microtonal beatings between close frequencies. Often morphing between pulsing and chaotic overall sound happens slowly over time.

Whilst only *Drift* and *Gala* are pure drone pieces, there are some similarities of inherent characteristics of *Mutation 2* and *When all memory is gone* to the material that makes up drone music. For example the difference tones as main material and similarities between how I morph between periodic and chaotic elements.

In *When all memory is gone* there are prominent moments where band pass filters and huge amounts of reverberation are used to boost certain frequencies into the foreground and at varying degrees obliterate the periodic bass drone of the original sound into a surge of foreground noise that equates to complete chaos. Durations of these contrasting moments increase and are used to create contrast to the otherwise low-end smooth periodic drones and mid spectrum glossy bell like frequencies. In a way similar to waves crashing on the beach with the high-end full spectrum noise happening as the waves break.

1.5. **Searching in between the grid – continuity**

Continuity of material is becoming a main subject of my music. Increasingly my imagination revolves around smooth long lines, waves, pulses, flickering, shimmering, vibrations, morphologies, distorted glows, slow morphs, gradual timbre transformations and extremely fine vertical proportions. When it comes to the notation of such material, the 'grids' or systems used for each piece come into question. Trevor Wishart talks about the problem of 'lattice-based musical organization'[53]. To execute these ideas, it is necessary to find non-grid based, non-

[53] See section 1.6.

linear approaches to the organization of time. Similarly when it comes to pitch organization, finer increments than traditional equal temperament are desired.

As far as time organization goes, I experimented with leaving certain aspects or parameters of a composition completely 'open' or free for interpretation by musicians and focus instead only on specific parameters that need exact control. For example, in most pieces the instrumentation is rather open. Instructions may read: 'For String Instruments'. In other cases timing is also relatively open with instructions such as 'Approximately 30 seconds per bar'. As far as the organisation of time goes in reference to being outside the grid, my approach has gradually shifted away from very complex rhythmic notation in favour of simple macro forms that expose rhythmically complex material. With this is meant micro rhythms are allowed to breathe within the time space allowed by macro events. Hand in hand with this approach then of course goes the search for material that already has its own inherent rhythm. Good examples are difference tone beatings, or glissandi crossings between instruments, or a Markovchain algorithm being applied to a series of parameters to create cloud-like textures. Rhythmic events happen so fast and in such multitude that it perceptually becomes one texture.

When it comes to pitch organization, my first approach was to make use of glissandi as well as musical illusions such as the Sheppard's tone to cross over the grid in smooth lines and avoid increments altogether. Again, flexibility can be found in score instructions such as: 'Glissandi ranges start and end pitches are indications only – choose your lowest and highest possible note and fit into duration'. The other major approach is to make my own grids. As part of this approach I have developed a useful Max/MSP patch to assist in tuning calculations. It also functions as a real-time router and converts frequency values to MIDI notes with MIDI pitch bend messages. It additionally gives values in cents and has useful ways to store lists of values (tunings) to recall at any moment.[54]

[54] See Appendix B.

Iannis Xenakis worked extensively with glissandi in many of his compositions. He said the following about the glissandi in *Metastaesis:* 'If glissandi are long and sufficiently interlaced, we obtain sonic spaces of continuous evolution.'[55] When this continuous evolution happens over extremely small vertical pitch distances such as in the music of Scelsi, for example in *Ohoi* (1966)[56] absolutely incredible beauty is revealed.

1.6. **Ordered Dissonance – Microtonal worlds**

In jazz music there's a term called 'going outside' the current modes/scales of 'fitting' notes to a certain chord progression or mode. It also refers to notes of high tension that want to be resolved. As a jazz pianist I was going 'outside' as much as possible and using as many chromatically dense clusters as I could. Searching for the weirdest chords in an attempt to get a new sound. Eventually I gave up the piano because the grid of semitone pitches was too wide for me, I was searching in between the semitone notes and couldn't get in there. I was searching for the finest shifts in colors similar to the sunsets and the difference between two semitones were just way too big. I wanted to work with instruments that can pitch bend much finer and switched to playing my violin processed with various effects as well as using the computer and samplers. I embraced the practice of making field recordings of noisy streets, fields, streams, ambient spaces and more, with an attitude of breaking free from the 'grids' of the music I had been exposed to until then. (With the word grid I mean the same as what Wishart refers to as 'lattice').

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[55] Iannis Xenakis, *Formalized Music: Thought and Mathematics in Music*, Harmonologia Series No. 6 (Stuyvesant NY: Pendragon Press, 1992), 10.
[56] Scelsi, *Ohoi,* compact disc.

I would often transcribe melodies from ambient sounds and double the ambient sounds with other instruments. Many sounds have inherent pitch curves. Similarly electronic effects and sampled sounds immediately gave me added rhythmic complexity in the material. The software I used (digital workstations such as Logic, Cubase, Ableton Live; and graphical programming languages such as Max/MSP) allowed me to work purely by ear, being in dialogue with the material instead of molding the material into my ideas. The difference between this aural approach to the organization of rhythm versus the possibilities of notation is again pointed out by Wishart:

> Thus, whereas aural rhythm takes place against the silent backdrop of somatic rhythm, enabling the aural musician to indulge in the most intricate articulations of time, notated rhythm is limited by the problem of notational economy.[57]

When working outside of notation in the purely electronic music context, this is not a problem. Especially when coding and working directly with processes such as generative algorithms or Markov chains to control parameters. Also working with field recordings as material was a kind of liberating process away from my ego, my subjectivity and myself. I could build up patterns that are directly inspired from the field recordings and often weirdly asymmetrical patterns were to be found inside the material. Setting it to a grid and meter would only happen much later, directed by the internal grooves found in the material itself. With this body of thesis works, I very deliberately wanted to approach music making from the other side: from the grid. To enable a better overview in my compositional thinking. Especially also to open new possibilities of collaboration with instrumentalists – thus exploring the benefits of notation as opposed to an aural only tradition.

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[57] Wishart, *On Sonic Art*., 23-24.

This process has led me to construct unique 'micro grids' and has opened up an exciting new level of control. One such example is leaving equal temperament behind for the time being, in favor of my own tunings.

1.7. **Color, Timbre, Tuning systems**

> One of the most notable developments in the composed music of the last decades of the twentieth century is the increasing attention paid by composers to tunings other than conventional twelve-note equal temperament. Now, in our new century, we have reached a situation where intonation, in the words of the late James Tenney, is one 'compositional variable' among many others – pitch vocabulary is now a decision to be made from piece to piece rather than a given, and is subject to as much variability as a composer's approach to rhythm, matters of timbre, texture and density, the approach to form, the use of space, and all other aspects of music.[58]

The movement and tension that comes from two tones that are even slightly out of tune with each other, the beat pattern, is probably one of the most interesting phenomena that I can think of in sound. Increase this intervallic distance and the beating separates into two tones. It is kind of like throwing pebbles in a pond with a smooth surface. From two tones to 6 to hundreds, the intervals and complex overtone movement is endless. Complex colours unfold. Adding real instruments to play these tones, means the instruments' individual harmonic spectral qualities are superimposed on top of these frequency patterns, adding to an even more mind-baffling complex weave of colours.

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[58] Trio Scordatura, 'Scordatura?' (http://trioscordatura.com/scordatura/, 19 January 2015).

One cannot embark on microtonal experimentation without coming across the work of Harry Partch. Known for his interest in notated speech inflections of various people that he met during travels and also specifically known for building or adapting instruments to enable his expanded tunings, for example the adapted viola that could play a scale with twenty-nine tones to the octave or his Chromelodeon—a 43-tone reed organ. The 43-tone scale contains within it all the pitches of the normal just tone scale as well as the amazing sounding ancient Greek enharmonic scale with its characteristic ditone (major third) and pyknon divided by two intervals smaller than a semitone called dieses (approximately quarter tones). These are not possible to represent by equal temperament.

Then there are the French spectral composers with their focus on the overall spectrum of the music as opposed to harmony, melody, rhythm and orchestration:

> Composer Tristan Murail speaks of the fusion of harmony and timbre into a single sound-object, which becomes the basis for his music. Dufort's description of spectral music mentioned the constant evolution of a sound's spectrum.[59]

A spectrum is quite often selected from an analysis of a particular note played on a specific instrument, with the particular characteristics of the way the note is played having an influence. For example loud, soft, on an open string or muted. Often several such spectrums are used or at least two of which one is more dissonant and one is more consonant. Such a spectrum is also referred to as a timbre chord. The music is then typically written to morph or transform from one spectrum to another. Or between more consonant sounding and more dissonant sounding in varying degrees to set up contrast.

As mentioned before, I am not interested in dramatic music with huge climaxes and linear drama. The opening material in Tristan Murail's *Désintégrations*[60] has

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[59] Anthony Cornicello, 'Timbral Organization in Tristan Murail's *Désintégrations* and *Rituals*' (Doctoral Dissertation, Brandeis University, 2000), 2.

[60] Murail, *Désintégrations,* compact disc.

the most wonderful colors; I just wish it never changes. This is actually a problem I have with some French spectral music. That the overall form concerns are back to creating linear drama. Working with expectation and release. However within many of these works can be found hundreds of brilliantly beautiful timbre chords or timbre moments, for example approximately 19 minutes into *Espaces acoustiques* by Gérard Grisey,[61] when the ensemble comes in behind the solo viola, the most incredible overall sound occurs and again at 19'20" where some of the strings glissandi against a dissonant chord played by the rest of the ensemble. Previously unheard colors and fantastic overall orchestration and music feature, I just wish sections would stay in stasis and develop differently over time.

When it comes to form, I feel more of an affinity for composers of the North American spectral music tradition ranging from the 1960s until now, composers all linked in some way to John Cage, including Tenney, La Monte Young, Maryanne Amacher, Phill Niblock and Glenn Branca. Ellen Fullman with her *Long String Instrument* has also inspired me. The approach to long duration drone forms or overall simple forms appeal to me.[62]

At the same time, my interests go beyond that of utilizing merely the spectral qualities of harmonic overtone series. I am quite curios to also explore completely artificial mathematical ideas – to listen them out.

In this regard, the work of John Chowning is highly inspirational. With his sharp ears and observations he radically impacted the development of electronic music.[63] Most relevant in this context, are his observations on the nature of non-musical sounds with inherent inharmonic structures. In *Stria* (1978)[64] he sets up a compositional system to control inharmonic spectra and creates a parallel

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[61] Grisey, 'Espaces acoustiques 1/2 - Ensemble intercontemporain'.
[62] As discussed in section 1.4 of this chapter.
[63] For example FM synthesis and spatial panning.
[64] Chowning, *Stria,* compact disc.

complimentary 'pitch space'. The inharmonic spectrum is structured with a pseudo-octave that is a power of the Golden Mean (Fig. 1).

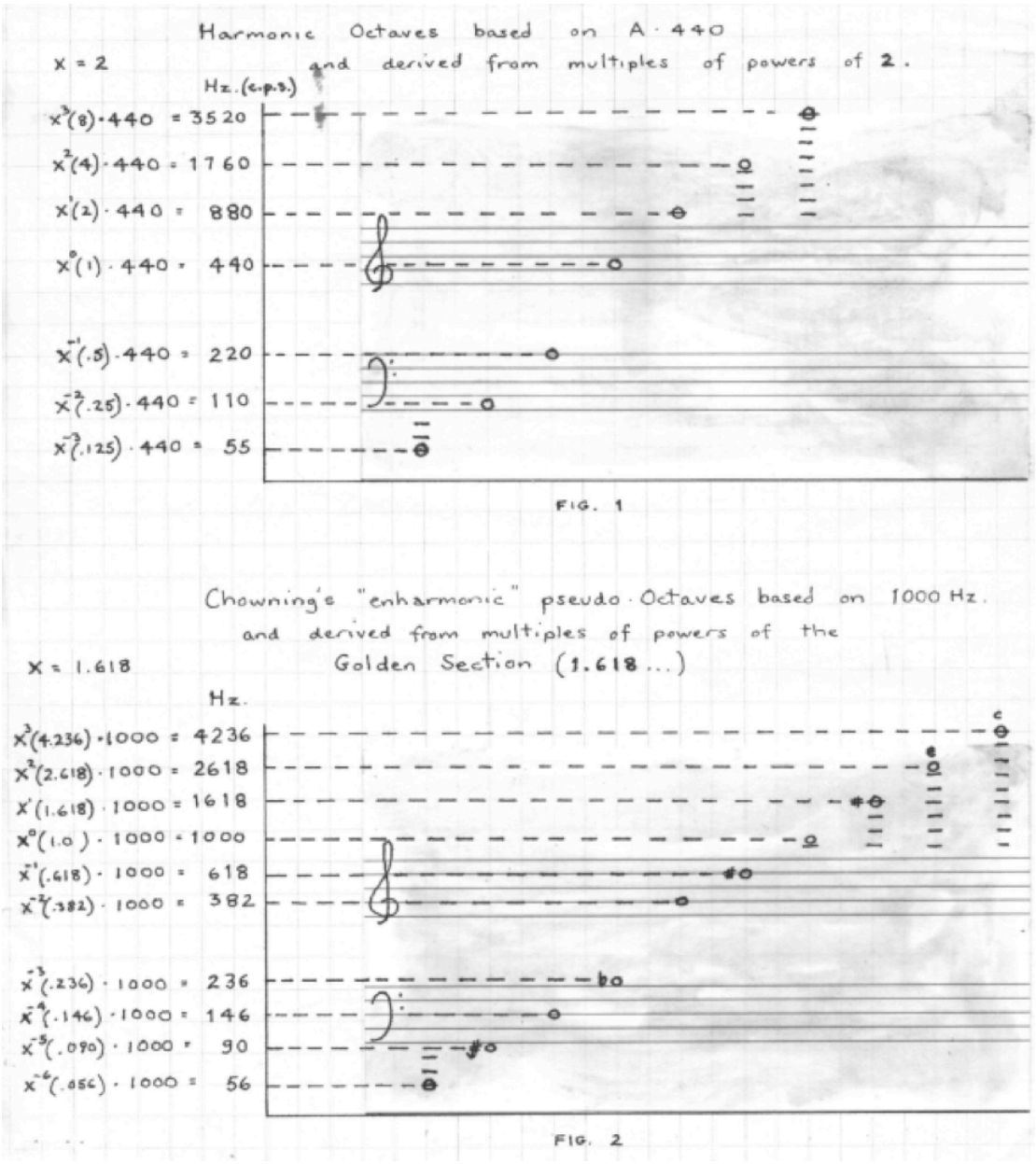

Figure 1: Chowning's Golden Mean enharmonic pseudo Octaves from 'Sketches for the Analysis of *Stria'*.[65]

[65] Toby Mountain, *Sketches for the Analysis of Stria* (Stanford University Archives 1980).

This frequency space is next mirrored (or positioned) against the harmonic series and tonality via the choice of a scale complimentary to the created pseudo-octave. This artificial system is 'an analogy' to the way the harmonic series relates to equal temperament:

> My interest began because it had a compelling kind of timbre in its simple FM synthesis formation used to create inharmonic spectra. So I started thinking about inharmonic spectra in relationship to a complementary tuning system as an analogy to the harmonic series and our common tempered system tuning system.[66]

This in itself is quite a radical statement that challenges the narrow confines of a system that has been used (and often blindly accepted as the norm) in Western classical and contemporary music for a couple of centuries. *Stria* goes on to eloquently demonstrate that there might just be an enormous amount of 'parallel universes' hidden in natural sounds that may seem to be chaotic (or inharmonic) but given the right observational power, may contain highly ordered patterns. It is just a matter of viewing them from a more advanced perspective.[67]

Stria's key ingredient is first of all material that is seductive to the ear:

> My whole interest is in what we can do that touches the imagination in a way that it has never been touched before. I was seeking a way of understanding some of these intricacies that existed in natural sounds. These sounds seemed to have components that are important to our perception, that are independent of whether something is natural or unnatural. Does the sound have a dynamic quality that is attractive to the perceptual system?[68]

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[66] Loren Means, 'Interview with John Chowning,' *YLEM* 25/COMPUTERS AND MUSIC (2005): 4-8.
[67] This thought occurs particularly because the overall pitch space quality in *Stria* reminds me of a very familiar nighttime insect soundscape that I vividly recall from camping in Betties Bay in the Cape Province of South Africa.
[68] Means, 'Interview with John Chowning.'

The material is also mathematically extremely elegant and functional: it allows for manipulation and mirroring across prominent musical parameters of the piece. In Fig. 2 one can clearly observe how the macro-level durations and the position of the climax, mirror the pitch space intervals.

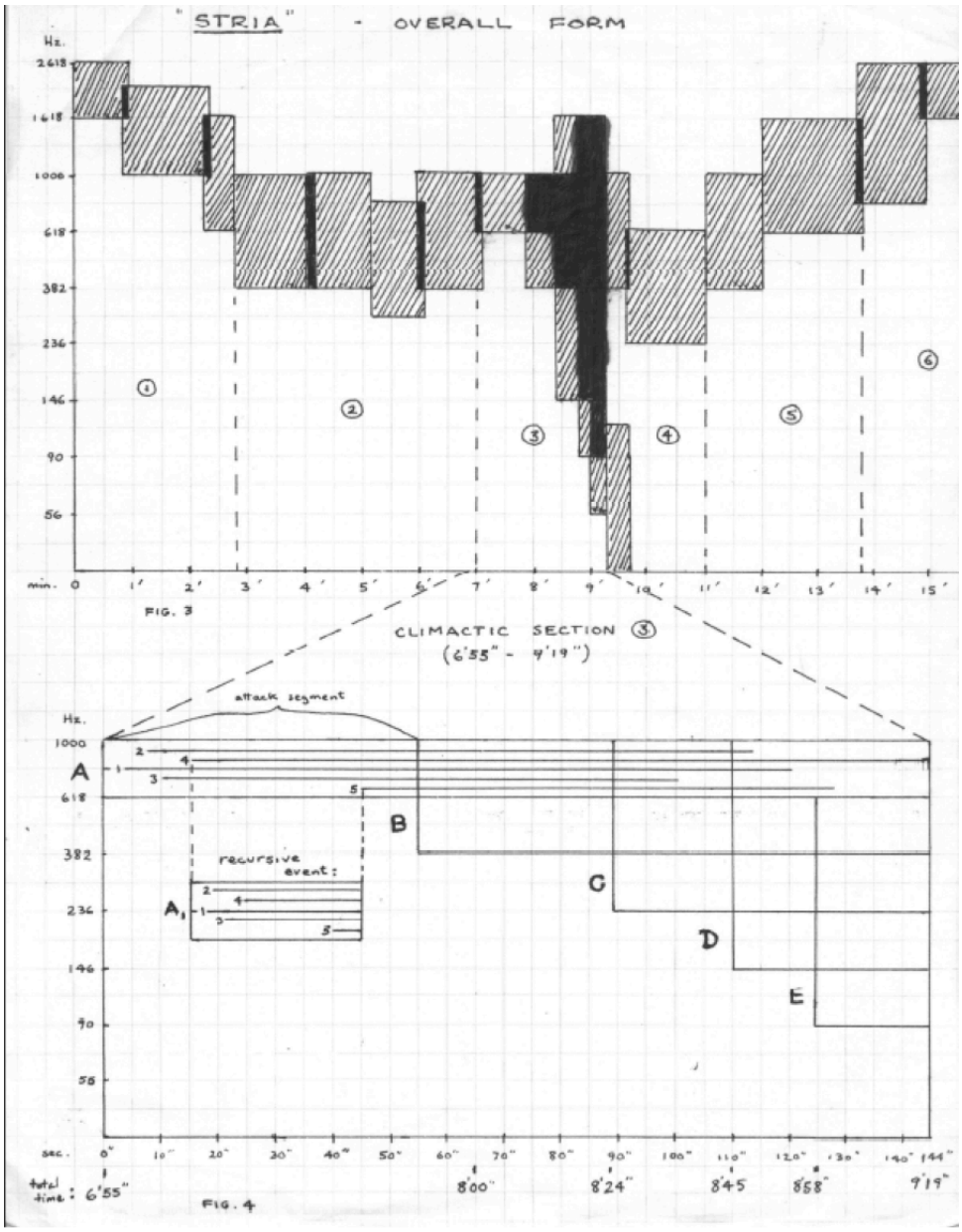

Figure 2: Overall form of *Stria* with the Golden Mean determining temporal structure and climactic section.[69]

[69] Mountain, *Sketches for the Analysis of Stria*.

At the micro-level, the carrier-to-modulator frequency ratios are also based on the Golden Mean. Then there is yet another observable mirroring between frequency space or "spectral space" and the time space with the use of a particular reverberation scheme:

> Time-varying, oscillator-driven reverb, consisting of several delay lines; has the effect of echoing the interference between almost coinciding spectral components.[70]

This fluidity across musical parameters is audible as the piece shape shifts and morphs and a deeper, hidden sense of structural integrity surfaces as a mysterious musical entity. *Stria* is probably the closest that music has come to demonstrate itself as a fractal, where all perceptible (and intentional compositional) parameters are structural mirrors of each other.

Inspired by this, I have worked with dividing the octave into 3, 5, 8, 13, 21 and 34 equal intervals. As you can see the series is the Fibonacci pattern. I have also combined all of these scales vertically in the same piece (*Haute Rorschach).* By layering 3-Tet, 5-Tet, 8-Tet, 13-Tet, 21-Tet and 34-Tet tunings on top of each other, the vertical pitch space gets an added dimension. It becomes a kind of meta-space containing intervals between different tunings. *Haute Rorschach, When all memory is gone, Drift, Gala* and *Mutation 2* all explore different combinations within these sets of Fibonacci numbered equal temperaments.

In *Haute Rorschach* and *When all memory is gone,* durations of effects such as delay times are mapped to be direct multiples of the wavelengths of pitches.
The effect is subtle but it implies mirroring and structural integrity amongst parameters.

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[70] Kevin Dahan, 'Surface Tensions: Dynamics of "Stria",' *Computer Music Journal* 31/3 (2007): 65-74.

I also use techniques of mirroring and reflecting in more organic ways, as growth processes. In *Haute Rorschach,* each fragment is mirrored to its inverse. This becomes a larger phrase. The process repeats itself. Intervallic pitch material of motives are also reflected in 6 superimposed temperaments, a motive starts at the smallest increments found in 34-tet tuning and grows larger in 21-tet, larger in 13-tet and so on.[71]

Jean-Claude Risset alters harmonic spectra via synthesis as compositional technique. In the first 8 seconds of *Mutations* (1969)[72] and at 6'21" in *Dialogues*, (1975)[73], one can hear synthetic bells and gongs created with harmonic spectra that fits the harmony of the current moment in the piece, thus morphing from harmony to timbre.[74] As already mentioned, normal bells and gongs have inharmonic spectra upon which a composer does not have the same control but Risset creates inter parameter moments of self-similarity or mirroring between a harmonic structure and a spectral structure that has an incredible sounding result. Another example of such a mirroring could be a timbral transition found in *Sabelithe* (1972)[75] by John Chowning. He creates a gradual transition between two timbres without cross-fade. Pebble like sounds transform into brass like tones.

Risset expands via additive synthesis the control of synchronous versus asynchronous moments in created sounds. He produces complex sounds by adding (harmonic or inharmonic) synchronous components and then also desynchronizes such components by shifting the successive components in time. Such a transformation from vertical (synchronous) motive to horizontal motive is very interesting in thinking about how form can be determined by vertical components.

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[71] See Fig. 29 in Chapter Four.
[72] Jean-Claude Risset, *Mutations,* vinyl.
[73] Jean-Claude Risset, *Dialogues,* vinyl.
[74] Jean-Claude Risset, *The Perception of Musical Sound - Computer Music, Why?* (University of Texis, 2003).
[75] John Chowning, *Sabelithe,* compact disc.

To jump back in time, Varèse's 'static pitch fields', as can be heard in the opening passages of *Déserts* (1954)[76], and the opening of *Intégrales* (1925)[77] in which the same notes are held, sustained or repeated for many measures, was a very new idea around the time of their composition (and largely influential on the Spectral composers).[78] This kind of repetition is an element I exploit a lot – it is again a form of minimal material, to repeat a single pitch over and over, as can be heard in *When all memory is gone,* in which the same pitches are shifted between instruments to achieve timbre variation. In *Fata Morgana* extreme repetition of notes are echoed between different voices and extended via delay units. These pedal point patterns are sustained throughout entire sections, with glissandi departing from each repeated note that in turn create dense textures around the repeated pitch fields.

Personally I enjoy being immersed in long stretches of extremely subtle *micro* dissonance. It gives sound a quality of melting. To be exact, like molten cheese – stringy or runny. Or similar to a mirage from heat waves on the horizon – that warping of image. This is why, from all the composers, Giacinto Scelsi is probably my biggest inspiration. Many of Scelsi's works are based on one note or chord, and thoroughly explore Schoenberg's *Klangfarbenmelodie principles*. Schoenberg said: 'Pitch is nothing else but tone colour measured in one direction'[79] and argued that pitch cannot be perceived without timbre or colour. From this he created theories around *Klangfarbenmelodie* or 'tone-colour melodies' and used it in his *Fünf Orchesterstücke* (1909). Anton Webern is also particularly noted for his use of tone-colour melodies.

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[76] Varèse, *Déserts*, vinyl.
[77] Varèse, *Intégrales,* vinyl.
[78] Cornicello, 'Timbral Organization in Tristan Murail's *Désintégrations and Rituals*', 16.
[79] Arnold Schoenberg, *Theory of Harmony*, Roy E. Carter (trans.) (London: Faber : Faber Music, 1978), 421.

The subject matter of Scelsi's music is timbre evolution and he does it with extreme control, subtlety and intrigue. This music pretty much tops the slowest of slow form and surface detail.

> Scelsi's timbral evolution provided an inspiration to composers who wished to "…exteriorize the inner reality of sound, to project its inner dynamics into an acoustic space and time…"[80]

It is incredible how in a piece like *Anahit* (1965)[81]; the music can be so expressive when so many parameters are limited. It is ethereal and oblique. The effect is incredibly strange, beautiful, but also uncanny: as if something is wrong with the image. As if one is looking at a crowd of people and then you notice they don't have facial features, no eyes, noses, mouths, just perfect skins. Or like having a lucid dream and you realize that you are inside a dream.

> Anahit is shaded with microtonal intervals (those intervals smaller than a semitone) as the various instrumental voices eerily twist and contort, incrementally sliding away from their respective starting points in mesmeric glissandi. Yet, the effect is never that of brutal dissonance. Instead the musical voices seem to circle each other furtively, occasionally coalescing into strikingly lucid harmonies before drifting apart once more: this music is perpetually expanding and contracting, slipping in and out of focus with intoxicating ambiguity.[82]

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[80] Moscovich in Cornicello, 'Timbral Organization in Tristan Murail's *Désintégrations and Rituals*', 30.
[81] Scelsi, *Anahit,* compact disc.
[82] Thomas May, 'Anahit, Giacinto Scelsi' (https://articulatesilences.wordpress.com/2012/09/13/anahit-giacinto-scelsi/, 2 March 2016).

1.8. **Texture**

Ligeti coined the term 'micropolyphony' to describe techniques that he used to create 'sound masses' that can also be seen as timbre masses and forms of *stasis*. Fast repeated phrases, sustained sounds, staggered instrumental entrances and the avoidance of pulse are some micropolyphonic techniques.[83] 'Micropolyphony usually involves thick, densely packed textures created from chromatic clusters.'[84] Individual elements such as harmony, rhythm, melody completely disappear in these sound masses as can be heard in *Atmosphères* (1961)[85] or *Requiem* (1965)[86]. In *Lontano* (1967)[87], there is an incredible timbral crescendo over the first 41 measures[88]: all the instruments of the orchestra play the same A flat, first the cello and a single flute start, the other flutes enter in staggered fashion, next the first clarinet (followed by the rest of the clarinets also staggered) and finally the next three muted bassoons.

Fata Morgana – Arrest 3 basically employs all the above-mentioned techniques with added tape delay effects to make the sound masses even denser.

1.9. **Physics of Sound and Acoustics**

It is already evident from my descriptions about electronic sound that the inherent physical properties of sound are prominent compositional concerns in my work. Studies in acoustics, physics of sound, digital signal processing, sound perception and sound art are informative to my ideas. In this respect there are four main interrelated aspects to elaborate on: Difference tones (also Combination Tones

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[83] Paul Griffiths, *Modern Music and After*, (London: Oxford University Press, 1995).
[84] Cornicello, 'Timbral Organization in Tristan Murail's *Désintégrations and Rituals*', 21.
[85] Ligeti, *Atmosphères*, compact disc.
[86] Ligeti, *Requiem,* compact disc.
[87] Ligeti, *Lontano*, compact disc.
[88] *Ibid.,* 21-23.

(CT) that cause third tones) with the resulting microtonal beating patterns. Then there is the *audio-physical* experience of sound, a term coined by Bernhard Leitner who is described as a sound architect. Next using acoustics as material (space as material) and related to this, spatiality in sound.

1.10. **Difference tones**

The main incentive to explore and develop my own tuning systems come from the idea of difference tones with a strong influence from sound art and Drone music. I really wanted to be able to notate smaller intervals than semitones for any musical instrument (as opposed to turning knobs on frequency parameters which is an easy way to create beating patterns and my initial form of experimentation). This in turn led me to explore the spectral composers as well as develop my own method of translating from frequency value to midi note (combined with pitch bend message) and cent value (as described in Appendix B).

The basic principle of a difference tone is that if you play two frequencies together, for example 100Hz and 110Hz, a third perceptual frequency will appear that is the difference between the two frequencies, in this case 10Hz. Newer research also reveals finer and more sophisticated understanding of this:

> In 1856 von Helmholtz was the first to identify sum and difference tones. For two sinusoidal signals with frequencies f1 and f2 such that f2 > f1, the sum and difference tones have the frequencies f1 + f2 and f2 – f1 respectively. Later on Plomp identified many additional combination tones with the frequencies f1 + N(f2 - f1).[89]

[89] Gary S. Kendall, Christopher Haworth and Rodrigo F. Cádiz, 'Sound Synthesis with Auditory Distortion Products,' *Computer Music Journal* 38/4 (2014): 5-23.

Here Helmholtz is quoted from his book *On the Sensations of Tone as a Physiological Basis for the Theory of Music* first published in 1863*:*

> These tones are heard whenever two musical tones of different pitches are sounded together, loudly and continuously . . . Combinational tones [also known as teni suoni, grave harmonics, resultant tones, subjective tones, intermodulation tones, aural harmonics, and heterodyne components!] are of two kinds. The first class, discovered by Sorge [a German organist, in 1745] and Tartini [the Italian violinist, in 1754], have termed differential tones, because their pitch number [frequency] is the difference of the pitch numbers of the generating tones. The second class of summational tones, having their pitch number equal to the sum of the pitch number of the generating tones, were discovered by myself.[90]

Microtonal beatings can be found in all the pieces presented, mostly as by product and intentionally as main material in *Drift, Gala, Mutation 2* and *When all memory is gone.*

When such beating patterns are played into a space through loudspeakers or via acoustic means, especially at loud volumes the sound becomes tactile and dynamic to the space. One can usually experience this by moving the head sideways or even moving forward and backwards in the space to hear different patterns. The listening experience thus become three dimensional and spatial purely because of the beating patterns. This phenomena of course occurs as side product of most music and resonant frequencies of listening spaces, but in this case the beating patterns have distinct spatial qualities.

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[90] John Fauvel, Raymond Flood and Robin Wilson, *Music and Mathematics - from Pythagoras to Fractals* (Oxford University Press, 2003), 78-79.

The next section is a continuation of thoughts around difference tones and other spatial effects, but with focus on the body and the architecture of the listening space as well as the invisible architecture of the sound itself.

1.11. **The audio-physical experience of sound**

Immersion in the context of Drone music has already been discussed. Further aspects that relate to the bodily experience of sound and space are influential to my approach. Bernhard Leitner has tirelessly produced a body of works and theories around the body related to the perception of space via sound for example *Reclining Chair with 6 speakers* (1975) in which sound passes literally underneath and around the body.

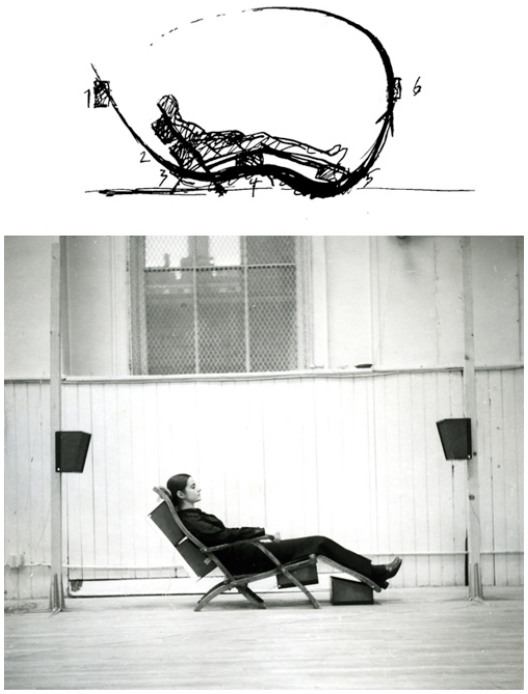

Figure 3: *Reclining Chair with 6 Speakers* (1975) by Bernhard Leitner.[91]

[91] Bernhard Leitner, *Reclining Chair with 6 Speakers* (Online, 1975).

Figure 4: *Circling Space* (1972)[92]

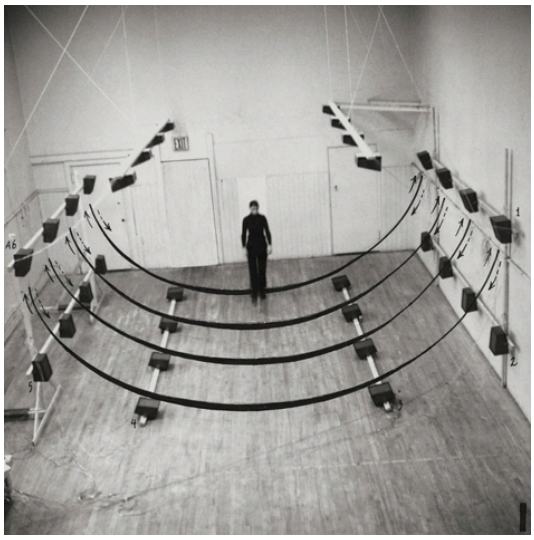

Figure 5: *Swinging Space* (1973)[93]

Figure 6: *Pulsating Silence / Tower* (2007)[94]

[92] Bernhard Leitner, *Circling Space* (Online, 1972).
[93] Bernhard Leitner, *Swinging Space* (Online, 1973).
[94] Bernhard Leitner, *Pulsating Silence / Tower* (Online, 2007).

> It is necessary to rethink and redefine the term "space". The boundaries of these spaces cannot be experienced at once, and they are not "dynamic, fluid" spaces in the conventional interpretation. It is space that has a beginning and an end. Space is here a sequence of spatial sensations – in its very essence an event of time. Space unfolds in time; it is developed, repeated and transformed in time.[95]

Even more extreme is the psychoacoustic phenomena referred to as *otoacoustic emissions*. High frequency sounds are used to create an inner ear distortion in the listener. This is not an auditory illusion but an auditory distortion referred to as distortion-product otoacoustic emissions (DPOAE). DPOAEs are one example of auditory nonlinearity or difference tones. In *Composing with Absent Sound*, Christopher Haworth points out that the ear is no passive receiver but 'an active transducer' in its own right:

> It [the ear] is a transducer, receiving acoustic energy and transforming it into electrical nerve impulses. Furthermore, as with other conversion mechanisms the relationship between the 'input' and the 'output' is not always linear, and it is from this interruption that the sciences of acoustics and psychoacoustics – respectively, the study of physical sound and the hearing mechanisms' transduction of sound - are derived.[96]

From this flows a rather unusual approach used by some composers to achieve a surreal level of immersion. Difference tones seem to jump from the exterior listening space into one's own head. I also experience tingling sensations in my eardrums. It is as if a sound hologram enters the ears and therefor the most

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[95] Bernhard Leitner, 'Artist Website' (http://www.bernhardleitner.at/texts, 30 October 2012).
[96] Christopher Haworth, *Composing with Absent Sound* (University of Huddersfield, UK, 2011), 342.

immersive experience I have had up to date. In Maryanne Amacher's (pioneer composer in this field) own words:

> When played at the right sound level, which is quite high and exciting, the tones in this music will cause your ears to act as neurophonic instruments that emit sounds that will seem to be issuing directly from your head ... (my audiences) discover they are producing a tonal dimension of the music which interacts melodically, rhythmically, and spatially with the tones in the room. Tones 'dance' in the immediate space of their body, around them like a sonic wrap, cascade inside ears, and out to space in front of their eyes ... Do not be alarmed! Your ears are not behaving strange or being damaged! ... these virtual tones are a natural and very real physical aspect of auditory perception, similar to the fusing of two images resulting in a third three dimensional image in binocular perception ... I want to release this music which is produced by the listener...[97]

Amacher combined the spatiality of architecture and external sound with inner ear sound. Most of her work was site-specific for example *Music for Sound-Joined Rooms* (1980) and *Mini Sound Series* (1985). From an interview talking about *Music for Sound-Joined Rooms*:

> In planning these effects, an important part is to distinguish, first of all, where the music is to originate. It might originate in acoustic space - out there in the room around us, as in a multi-speaker configuration, where you might have distant sound, sounds moving around the room in circles, spirals, squares, or other shapes. Or it might be in intense close-up, concrete, locatable. Or it might come from the stage in front of us, as is usually the case. And then we have the interaural space, and that's here within us - that's what I characterize by 'head-born sound' and 'ear-born sound'. What excites me

[97] Pieter-Paul, *Played at the Right Sound Level* (Displaced Sounds, 2009).

> musically is the interplay of aural and interaural sonic imaging. The convergence of these perceptual dimensions is really the main idea - a multi-dimensional construct. As yet I don't know what to call it. For now I call it 'psybertonal topology' - the mapping of interaural spatial imaging with acoustic spatial imaging.[98]

This is a really interesting point of view. In a way like sitting in a movie theatre and then suddenly you see a character that was on the screen minutes ago sitting next to you. Something uncanny about it all. She is talking about mixing external sounds in the space and layering them with, or moving them inside the head. One can almost say her work's form is psycho- architectural music.

The material in *Mutation 2* consists of various difference tones created by intervals from my 21-tet and 34-tet scales. The sounds are that of a Clavia Nord Rack 2x synthesizer and are in a way smooth but harsh. The piece needs to be played at a relatively loud volume to create the tactile effect. (Also the effect does not work over headphones). The room is filled with third tone pulsings and otoacoustic moments happen. What is really interesting to me is experiencing the wavelengths of these patterns so literally: when you move your head slightly forward or backward you can step into the nodes of the waves – it is undeniably there. The effect is that when you are not in a node of crossing you hear two tones, when you move your head into a cross point you suddenly feel an active vibration. At certain moments the ears start tingling and the note jumps into the head. Instructions for the performance situation includes that the audience need to move around the space freely. As the pitches change over time, the distances required to move the head in and out of the beatings change. So this becomes really interesting spatially – one parameter of the music is to 'move to feel the nodes'.

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[98] Handelman, 'Maryanne Amacher - Ears as Instruments: Minds Making Shapes.'

The otoacoustic moments in this case happened as a lucky chance by-product, originally I didn't intend for them to happen and they appear randomly during this piece. In future I would like to direct and control this more consciously.

Because the listening space (or architecture) is such an active component in this phenomena to work, the most successful work in this field are inherently site-specific. This can be confirmed from Amacher who usually almost live in her performance spaces in advance and spend days setting up and modifying the piece to work in a space. She says that the last part of the composition actually happens in the space. Talking about *Synaptic Islands: a Psybertonal Topolgy* that was installed and performed in Tokushima, Japan she says:

> I'm learning the characteristics of the space. […] I was mixing sounds staged in two totally different rooms. One of the rooms was a curved stone passageway that was like an old Gothic castle, and it was a fantastic space acoustically, but there was a clear 10 dB difference from the main space, where I was mixing. You can make spectacular acoustic effects with these different acoustics, if the audience is listening for a time in one space and suddenly the sound begins making something in the other. The two may interact, or fuse, or be utterly separate, or melodies may drift between the two. Sometimes the sound was not locatable, sometimes above you, on top of your head, directly inside your ears, inside your head. I was really able to realize this idea of a psybertonal topology at Tokushima, having it develop in aural and interaural imaging that actually bypassed even the two physical spaces. And I discovered something there I'd never heard before. In the stone curved room this whole enhancement shapes, the interaural and melodic shapes and patterns we perceive in this interaural imaging - this was completely enhanced. It was like an actual image that you could almost see and touch. I've never known that to happen before. The space was enhancing something in the sound that further intensified the neural shaping that we give to these melodies, but it was like the perfect shape. So

> now, all I think about is an architecture that could really do this, that would be so extraordinary.[99]

Thomas Ankersmit performs live with analogue synthesizers creating very effective improvisations in this area, whilst Yoshi Wada, Matt Ingalls, John Butcher and Tony Conrad have done so acoustically. Phil Niblock applied microtonal pitch shifts to enhance occurring combination tones which is a main feature found in *3-7 169* (1974) for Cello and Tape[100]. Christopher Haworth explores different approaches to DPOAE's in a paper called *Composing with Absent Sound* (2011). He points out that in Niblock's music 'the effect is mostly subliminal' whilst with Amacher the focus is a 'dissonance between the acoustic sound 'out there' and the DPOAE sound 'in here'. In turn Jacob Kierkegaard makes the DPOAE the explicit subject of his 38-minute work *Labyrinthitis*[101] with an interesting approach to form:

> The piece begins with pairs of sinusoidal tones used to excite a DPOAE in the listener's ears. The precise frequency of the DPOAE produced is then used to supply the next acoustic tone which will be introduced, meaning that the ear becomes an active participant in the work - it 'tells' the piece which frequency to introduce next and the work responds, creating a cascade of tones that mirrors the shape of the cochlear.[102]

Haworth's own piece *Correlation Number One* demonstrates a more nuanced control of DPOAEs by manipulating the stimulus frequencies. He developed a

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[99] Eliot Handelman, 'Maryanne Amacher - Ears as Instruments: Minds Making Shapes' (https://web.archive.org/web/20120825215513/http://www.colba.net/~eliot/amacher.htm, 3 March 2016).
[100] Niblock, *3 to 7 – 196,* compact disc.
[101] Kierkegaard, *Labyrinthitis,* compact disc.
[102] Haworth, *Composing with Absent Sound*, 343.

mathematical system in which the acoustic stimulus frequencies are calculated in reverse leaving the composer to compose 'with absent tones'.[103]

During my MFA studies with Paul DeMarinis at Stanford, our sound art class installed and performed a version of David Tudor's *Rainforest. Rainforest*[104] consists of (mostly large) found objects of metal, wood and other materials with transducers attach to each object so that it functions as a loudspeaker. We were free to send any sounds to these objects. The frequencies in the audio resonant with each object's inherent resonances would be the most audible. The result really made a big impression on me, not only as how sculptural it was, but especially the idea that nearly any object with the right density could function as a loudspeaker. I put transducers on everything I could find, including my studio's windows and it was not long before the idea hit me to bite on a piece of metal extending from the transducer and magically listen to the sound playing through my own skull, jawbones and teeth. This was really one of the weirdest listening experiences I have had up to date.

Thus began the awareness of inner ear, and body/skull/bones vibrations. Sound as vibration not only limited to the typical ways of hearing but sound as waves in space, colliding and interfering with each other, bouncing off the walls, folding back on itself and repeat. Also sound traveling through different objects and different densities.

At the same time, a friend who was undergoing chemo treatment for cancer showed me a device that she used for additional treatment: a *Cymascope*. This device is basically a small box that looks like a vintage telephone with high quality oscillators and a huge round speaker that one can lift and move over the body. Up to 5 frequency combinations can be 'dialed' into the device to produce the sound. Without going into much further details here, the concept is basically that each cell

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[103] *Ibid*., 344.
[104] Tudor, *Rainforest*, compact disc.

in the body, each organ, each disease and each emotional state have resonant frequencies and these cymascopic patterns are there to assist both physically in making the cells of different areas in the body resonate as well as emotionally in focusing on the sound.

The microscopic pitch clusters were on a purely sonic level really intriguing to listen to. I copied the lists of frequency combinations and build a Max/MSP patch to play it. From here on started my interest in microtonal beatings – their strong spatial element and weird behaviour at different levels.

I found myself extremely lucky to have a residency at Naut Humon's *Compound* (with a similar set-up than the infamous Recombinant Media Lab theatre) with a surround rig of 16 speakers and 8 woofers with the possibility to route individual tracks of audio to each individual speaker and woofer. Mapping Cymascopic patterns to different speakers (each frequency to a unique speaker) the room turned into a mesh of flickering, vibrant pulsing entities. I noticed the extreme differences in experience at different volumes. When turning my head as little as 1 cm the rhythmic pulsing pattern would completely change.

One could compare the flickering to strobe lights at different tempos. It has a disorienting, hallucinatory effect (when played at loud enough level). At once putting the listener in a kind of isolation that may feel subliminal. This also has a powerful effect of being in the absolute 'now' or present – there is no tempo insinuated, only the constant bombardment of flickering rhythms. Overall it made me feel sick though, the dissonance was extreme and the inherent quality of the sound oscillators used in Max/MSP was digital and harsh.

Inspired by Leitner I created a sonic bed, *Infrasound Bed* (2011) in Cape Town in which the listener experiences two part counterpart music via headphones on the one (hearing) end and physical infra sound vibrations via bass shakers screwed into the frame of the bed, on the other end. This time, I used pure frequency tones

recorded of tuning forks, created difference tones and modified some to glissando up or down. Next transposed material way down into the 7-15 Hz range and used a special amplifier to activate the shaker. The effect was tremendous. The bed was shaking! Most interesting was creating continuation between tactile vibration and the audio spectrum. For example a high pitch would slide down to the bottom of the headphones reproduction capability and then cross over into fast vibration in the bed to slow down into a pulsing – in a smooth continuous curve. Or I would have parallel motion, or opposite motions in the two ranges. Unfortunately the Amp was so expensive I could only hire it for the duration of the festival and that was the end of the experiment.

Figure 7: *Infrasound Bed* (2011)

Ellen Fullman is known for her *Long String Instrument*, with which she has been exploring acoustics of large resonant spaces and creating numerous compositions. She was inspired by Alvin Lucier's *Music on a Long Thin Wire* (1980)[105] and the idea of a child's cup-and-string telephone. The instrument consists of wooden box

[105] Lucier, *Music On A Long Thin Wire*, compact disc.

resonators that are mounted at one end of a room, with 22 strings extending across the room to another fixed point and are tensioned using harp pins in tuning blocks. The instrument is played by "bowing" with rosined fingertips while walking. They are tuned using mathematical ratios, or just intonation, and their pitch range is determined by length, for example A4 (440 Hz) spans 8 meters in length. Every octave lower requires a doubling of length.

Fullman describes an optimal bowing speed that brings the strings to life. For her the difference between optimal and any other is "like the difference between a sensation of jagged shards of glass sticking into my ears and a feeling that the sound has plasticity and can be molded with my fingertips into undulating shapes, like a string of beads".[106] Fullman also studied North Indian vocal music with Anita Slawek in Austin, who taught her how to slow down, focus and told her that when she is really in tune the music will play itself. She applies this not only to her own concentration as a performer but to the physical tuning of the strings as well:

> When the tuning is really clean, it is as if I am running a giant mechanically geared clock, each string like an individual gear of larger or smaller diameter, rotating at its own rate in relationship to the other gears in an overarching system that is aligned to eventually repeat.[107]

1.12. **Spatial elements - Acoustics**

I consider artificial acoustics (achieved via subtle to extreme reflections at different frequencies, delays, equalization, distance ques and more) as very important parameter of the music. Musical sounds/grains behave almost like bats sending out signals to test the space. Or pebbles in the pond to see the texture of

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[106] Ellen Fullman, 'A Compositional Approach Derived from Material and Ephemeral Elements,' *Leonardo Music Journal* -/22 (2012): 3-10, (7).
[107] *Ibid*., 8.

the surface (liquid ripples). Acoustically speaking, it is in a way a very literal 'negative space'. Since there is no such thing as silence, especially in electronic music, but actually in all listening settings, the acoustics or resonant space(s) in which the music rings are equally important to any other musical material.

For each sound in a piece as well as the overall sound I imagine this negative space: does the sound belong in a matchbox size space? In a cave or in a huge cathedral? In a tunnel or in a large empty industrial factory? Under water or in hole dug in the ground? Or in a black hole? What does a black hole's acoustics sound like? Does the space shape shift-over the progression of time? Are the surfaces of this space velvet or marble? Or is it a close up next to somebody?

In this regard there is a lot to learn from the field-recording artists such as Chris Watson, Lawrence English or Jana Winderen previously mentioned in the context of Drone. An immense amount of detail is captured and revealed from the soundscapes. Elements such as acoustic texture, openness or closure, distance, perspective, reflections, surfaces and densities (for example in the case of underwater hydroponic recordings) are revealed.

A lot of spatial concerns have already been discussed as they exist in the context of electronic music, drone and sound installations.

1.13. **Spatial elements – Extending instruments and sounds**

In *When all memory is gone* and *Fata Morgana - Arrest 3* I use a reverb sample-and-hold function that feeds back on itself, keeps swelling in loudness. It is a very effective way of extending specific notes and building up drones and spectral swells. Many of the drone musicians use this effect via hardware or software effects or synthesizers.

Tape-delay is another useful tool to extend instruments and is again widely used, for example in James Tenney's string quartet version of Saxony (1978)[108]. Pitch material from a single harmonic series is gradually revealed with a growing density in texture because of the use of delay effects catching the long tones and phrases and feeding them back into the texture. Inspired by Tenney I use the same effect in *Drift* and *Gala* to extend, build up density and smooth out transitions between notes played by the violins and Norwegian hardingfeles as well as in *Fata Morgana – Arrest 3* to extend the voices.

1.14. **Conclusion**

An overview of compositional interests and influences has been presented especially in terms of overall aesthetics. The main elements are form, color and space and how these combined create movement. Specific composers and sound artists have been discussed in terms of their use of minimalist material, surface, extreme duration, color, timbre, texture, space and auditory perception. I have presented an overview of composers with unique microtonal or spectral approaches to composition, the use of difference tones and the awareness of spatial elements as important musical material. It has been illustrated each time how these elements feature in my work.

Next follows a detailed commentary on each piece in the portfolio.

[108] Tenney, *Saxony,* compact disc.

Chapter Two: String Quartet No. 1

2.1 Introduction

With *String Quartet No.1,* I wanted to create a piece that starts with a single forward motion similar to a brush stroke, a very simple gesture, that happens once, then starts again and extends slightly further, then starts again and extends even further and continues like this for a very slow and long time. The effect in my mind like playing a film or tape from the start for 20 seconds, stop, rewind, start over, now play for 21 seconds, stop, rewind, play for 22 seconds, stop, rewind… as if searching for some forensic clue. Moving at a painstaking pace through the tape (and piece).

Because memory is dynamic and because emotion and subjectivity interferes during the process of observing the same thing, the experience would be different each time the tape starts again at the beginning – these differences would be written into the music by me.

In parallel another related image was quite strong in my mind: looking at replicas of the same painting hanging in a perfect row in a gigantic room in a museum. Each motive would represent the amount of time one stands in front of the painting. Moving on to the next one, one sees yet again the same painting, yet, because of its ambiguous content, one is never sure about the similarities and differences – perhaps the angle of the single brush stroke is slightly different? Or perhaps the thickness of the paint and density of color is slightly more intense in places different to the previous view? As information overload sets in (let's say by painting number 49), the experience becomes a blur, as if the room starts spinning until some sort of epiphany happens and the same lines folded out over the entire

space: longer, exaggerated as if time now has slowed down or the size of the viewer relative to the size of the painting has dramatically changed.

2.2 Form

On the macro scale the form has a basic ABA structure: The opening section consists of repetitive gestures that build up in intensity for just under half of the total duration. With each repetition the glissandi stretch slightly bigger in duration and further in pitch from the origin. First the instruments move in parallel lines, each instrument departing and approaching unique intervals. This results in a multitude of microtonal crossings. At times an instrument may need to cover a small pitch distance, such as 2 semitones over a long time, such as 7 bars – so the slow pitch transformation is extreme. Eventually directions of glissandi between the instruments are in opposite motion or a glissando may also change direction in the middle of the gesture for one instrument, whilst the others continue.

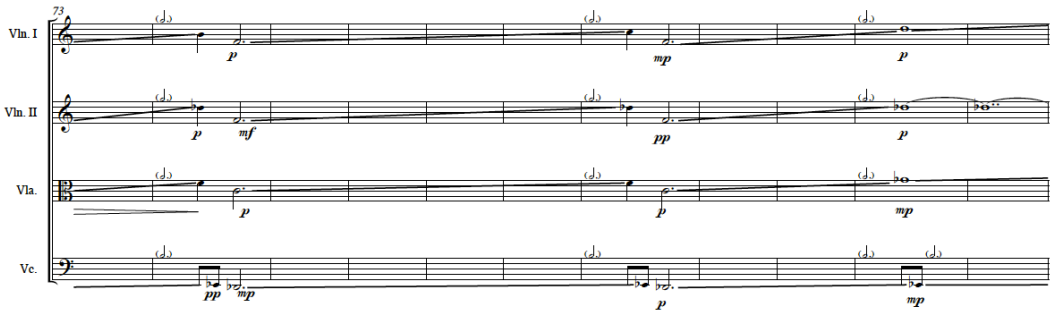

Figure 8: Glissandi motives with rhythmic unison and parallel lines at different intervals.

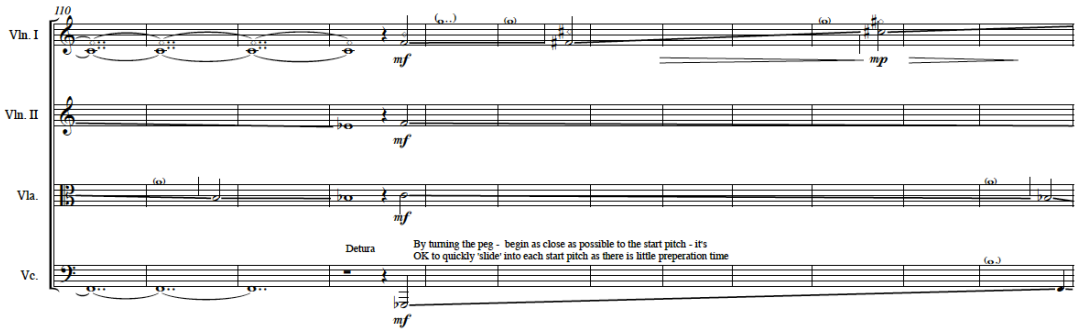

Figure 9: Rhythmic unison, opposite directions and change of direction during gesture.

In section B, the macro rhythm and timbre change simultaneously. From unison rhythmic gestures to finally a rhythmic offset between the 4 layers as well as the introduction of harmonics for a dramatic change in timbre and drastic increase of activity in the spectral high end. As if light and with it lightheartedness appears. Gliding and swinging motions. As if solitude disappears there is for the first time some kind of dialogue between the instruments and some melodic and harmonic moments are created.

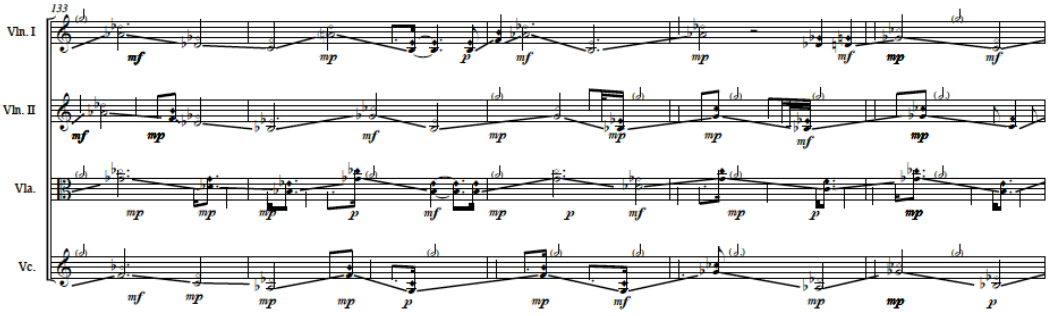

Figure 10: Harmonic glissandi, rhythmic activity amongst voices.

Then a sudden return to the initial material (A) but with a more harmonious sound of resolution, and much larger slower glissandi with more bass in the cello.

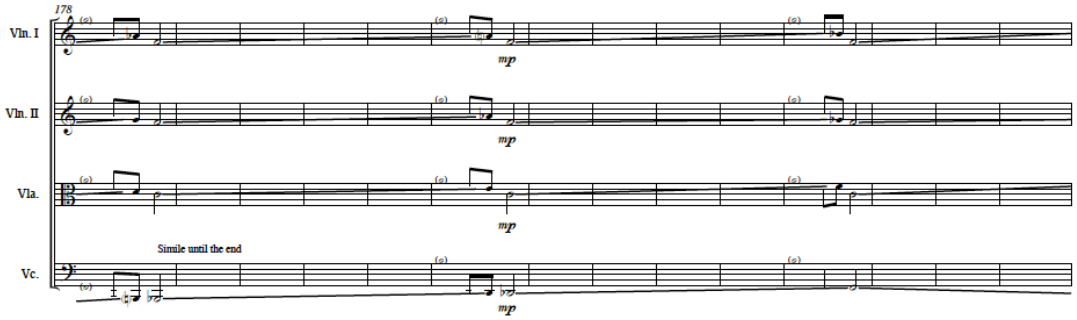

Figure 11: Material similar to beginning.

2.3 4 Lines – Macro/micro meta space

The macro gestures that make up *String Quartet No. 1* consist of 4 lines that move via glissandi, as smoothly as possible by human players and the instruments of a string quartet. These macro events are on paper really simple lines, yet the ratios between lines (or negative spaces) are very dynamic. It also takes extreme concentration from the performers since they are expected to move in micro increments, even when that sometimes means sliding up a single semitone over a long duration. They are asked to listen out for each other and for the microtonal beat patterns that inevitably happen.

The proportions of glissandi durations are based on proportions of the Fibonacci series (1,2, 3, 5, 8, 13,).[109] I set out to make initial drawings to get an idea of the time proportions first:

[109] There are so many factors that attribute to the perception of musical durations, that I don't really think it is audible per se that I am using these numbers for durations. One could say it is rather a compositional game or visual reference point. I am drawn to Fibonacci proportions especially how they feature in the spirals found in certain seashells.

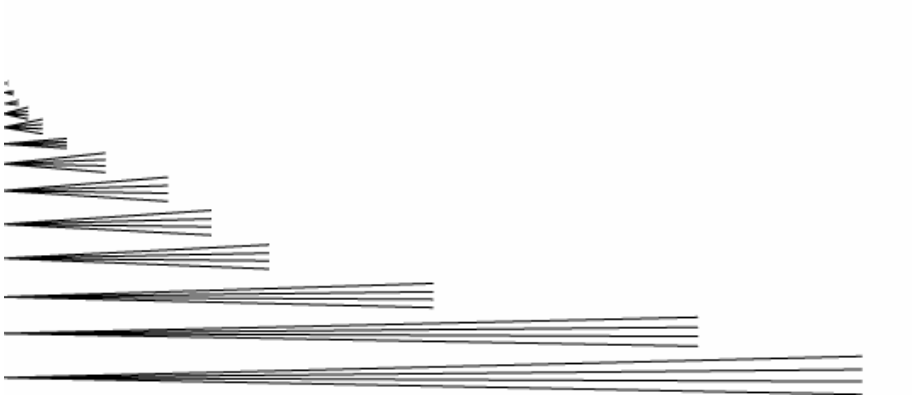

Figure 12: Sketch of glissandi durations according to Fibonacci proportions.

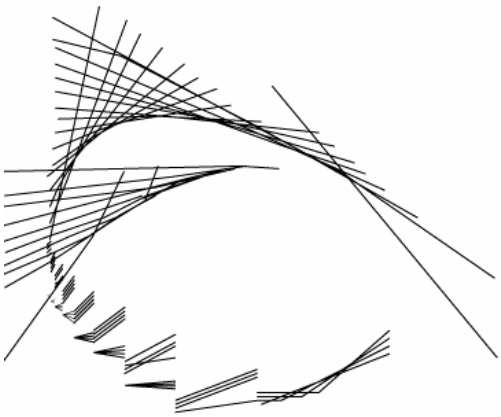

Figure 13: Experimenting with glissandi curves and shapes

Xenakis[110] also makes elaborate use of the Fibonacci sequence to determine duration and a range of timbres.

> In Metastasis one is not aware of individual sounds but of a new mass of sounds and timbres. The means by which he achieved this were derived from *The modulor*[111] of Le Corbusier: pitches (based on twelve-note rows) were

[110] Xenakis, *Metastasis,* compact disc.
[111] 'The Modulor consists of two sets of harmonic numbers, that is to say that the ratio of two following values in the set corresponds to the Golden Section while each value

assigned a series of durations based on the Fibonacci sequence, along with a range of timbres. The way in which this material was processed became the form of the piece.[112]

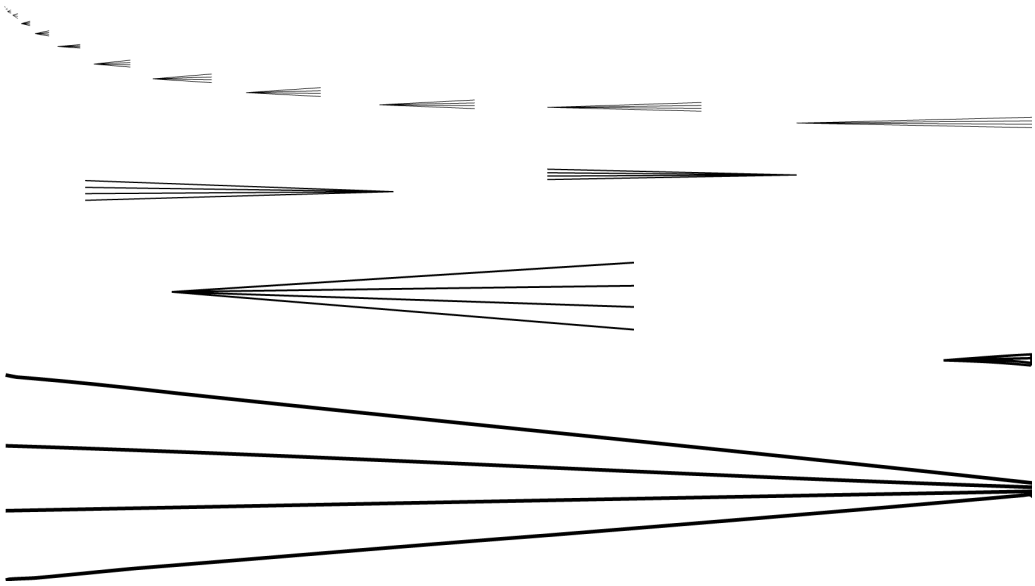

Figure 14: Sketch of glissandi overall form and proportions.

The interesting problem for me arises of how to deal with events that are too large in proportion to fit into the image – as you can see the Fibonacci spiral grow very large very fast! One idea was to fold over the event to continue in opposite direction. For example change direction (up/down) of glissandi.

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is the sum of the two preceding ones. One set is based on the number 226 (the length in cm of an average man, arm raised), the other on the number 113 (the distance between the ground and his navel). Le Corbusier summarized the theoretical background of his invention in his book Le Modulor' Sven Sterken, 'Music as an Art of Space: Interactions between Music and Architecture in the Work of Iannis Xenakis,' in *Resonance: Essays on the Intersection of Music and Architecture*, Mikesch Muecke and Miriam Zach (ed.) (Ames: IA: Culicidae Architectural Press, 2007) 21-52.

[112] Fauvel, Flood and Wilson, *Music and Mathematics - from Pythagoras to Fractals*, 145.

The next sketch show variations of vertical proportions in start and end pitches of glissandi. One voice will slide up an interval of a minor third whilst the other will slide a fifth. Two voices can start on the same note, but end on different intervals. Voices can slide in opposite directions. Crossings can happen. As one can see, the four instruments are mostly in unison in rhythm until the point of change (in the sixth row of events) when voices 'chase' each other (looks like a geometric mountain range).

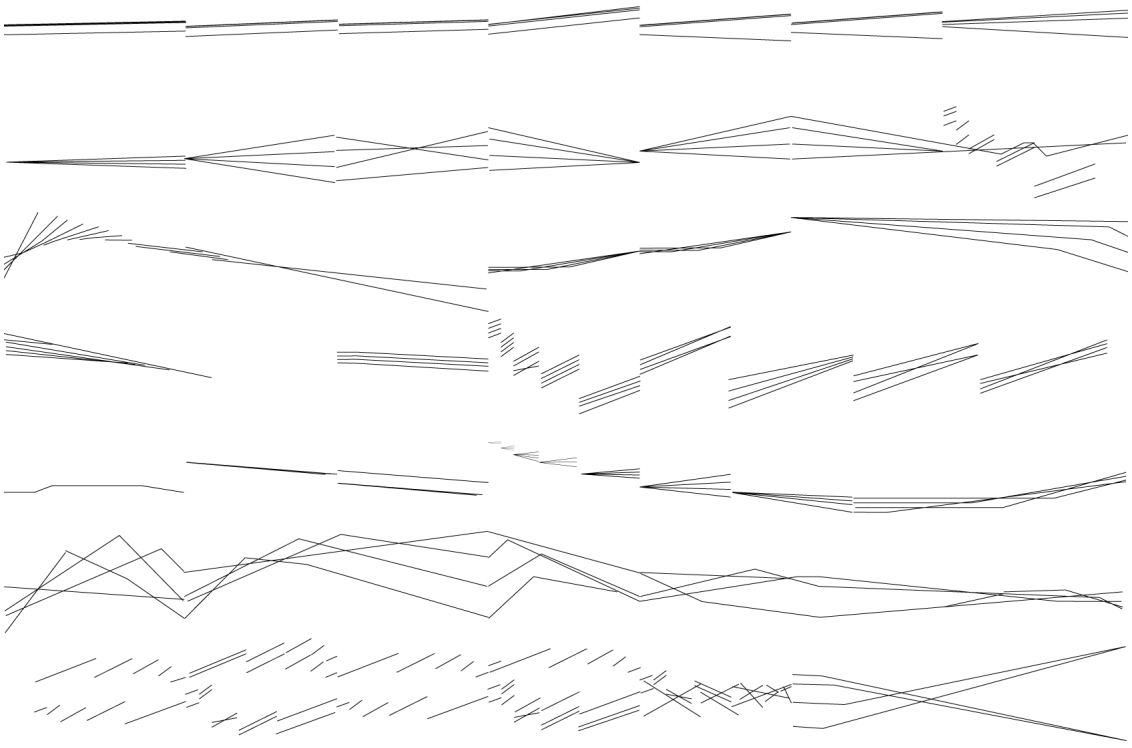

Figure 15: Sketching out glissandi variations: 4 lines = 4 instruments.

2.4 Glissandi as continuum

Iannis Xenakis worked extensively with glissandi in many of his compositions. He said the following about the glissandi in *Metastasis:* "If glissandi are long and sufficiently interlaced, we obtain sonic spaces of continuous evolution".[113]

I am using a maximum of 4 parallel layers at any given time; simple manipulations on the macro scale events create continuous subtle microtonal evolution that at times sound like extremely dense chord progressions. As 4 intervals continuously expand, shrink or cross, the subtle space of microtonal patterns between them is a dense, ever-changing tapestry of pitch combinations and spectral patterns. Timbre changes of each instrument as it slides through different registers enhance the sound to be even more delicately active.

> The idea of continuity – in the sense of the continuous but (almost) imperceptible transformation between two discrete sonic states (loud-soft, high-low, fast-slow) – was central in Xenakis' theoretical preoccupations at that time. More specifically, he wondered how a fluent transition between two sets of notes could be obtained.[114]

Thinking in terms of 'lines' as opposed to individual notes is quite liberating. With a glissando, the grid of notes completely disappears and one works directly with lines. There is no tuning, no temperament, no semitones or scales, just a smooth line between A and B, be it conceptual. A great player will accept the challenge and meditate or zone in on the infinite amount of microscopic transitions hidden between the dots of the line. It reminds me of Radigue talking about the

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[113] Xenakis, *Formalized Music: Thought and Mathematics in Music*, 10.
[114] Sterken, 'Music as an Art of Space: Interactions between Music and Architecture in the Work of Iannis Xenakis.'

'mysterious power of the infinitesimal'[115]. Lines then, can also be the building blocks of even more dynamic shapes such as curves and curved spaces. Xenakis realized that straight lines combined could create curves, which map out the glissandi in *Metastasis* (Fig. 16). He even applied this in physical space in the design of the fabulous Phillips Pavilion.

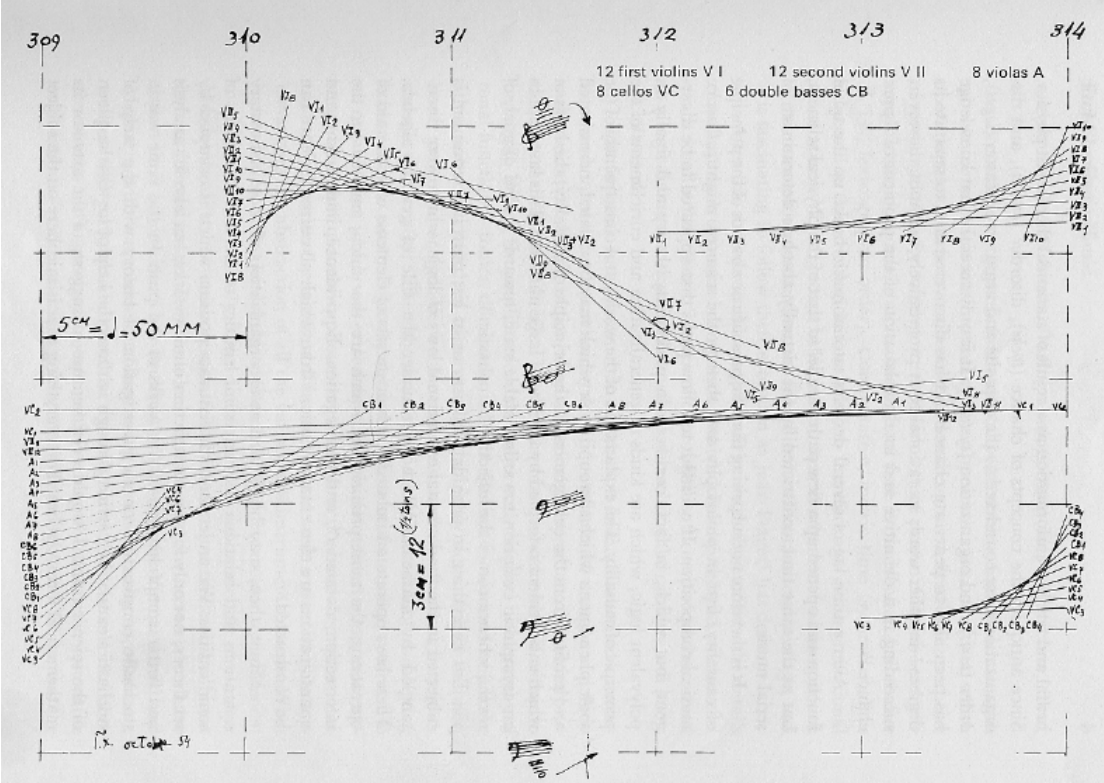

Fig. I–2. String Glissandi, Bars 309–14 of *Metastasis*

Figure 16: *Metastasis* String Glissandi, Bars 309-14.[116]

[115] Julien Bécourt, 'Éliane Radigue: The Mysterious Power of the Infinitesimal' (http://daily.redbullmusicacademy.com/specials/2015-eliane-radigue-feature/, 1 March 2016).

[116]Xenakis, *Formalized Music: Thought and Mathematics in Music*., 3.

2.5 Intuition versus plans

In the final outcome of *String Quartet No. 1,* there are various deviations from my sketches and planning. Often mathematical ideas inspire and initiate a piece, but I prefer to work intuitively at the end. Rules are meant to be bars of a ladder and not of a prison cell. To some extent, during my compositional process, the image or maps are not so much about measurements than interpretation of intensity, depth, movement and energy. If I followed the pre-sketched plan exactly, I would lose the intuitive fun part and it would not be art at all.

2.6 Spatial elements

In the performance notes I indicate a preference for the piece to be performed by more than one actual string quartet playing in unison but allowing for physical spatiality via the positions of the players. In the case of 2 quartets, the one should be placed at a higher, raised level from the other, with at least a meter height difference and up to an entire balcony versus floor difference. In the case of 3 - 7 quartets, they can be arranged to surround the audience in an interesting way, considering all directions as well as height differences. Ultimately, I would like the listener to be completely immersed and surrounded in the melting glissandi.

There are various composers who have experimented with ideas of positioning players around the audience or even in different rooms with the audience moving freely around and thus lending a very special dynamic listening atmosphere to the work. For example *The Partenheimer Project* (2007*)* by Kevin Volans in which 3 ensembles play in 3 different spaces, but each able to be overheard by the others. (In his case they also play different material at different speeds). Or the infamous

Poeme Electronique (1958)[117] by Edgard Varèse for three-track tape, ten amplifiers and 150 loudspeakers positioned at various points throughout Le Corbusier's and Xenakis' structure, so that the music recreated the shape of the building itself. Or Stockhausen's *Gruppen* (1955-1957)[118] for a large orchestra divided into three orchestras each with its own conductor and deployed left, front and right of the audience. The spatial positioning was partly motivated by simultaneously played but different material at different tempos by the different orchestras. There were also passages in which a single musical process passes from one orchestra to another.[119] Such a dynamic must have been sensational.

My string quartet spatialization is much simpler but nevertheless effective, since no two players can play exactly the same glissando (and they are instructed not to match bowing) it means that texturally there will be simply more opportunity for spectral diversity in the thousands of microtonal fluctuations, resulting in an ever richer amount of detail, amount of interference patterns and depth. The vision here is to create a feeling of the listener to be floating on a boat in the middle of the sea and surrounded by 360 degrees of (sound) waves.

This may also point to a general new direction for me in spatiality: my earlier works were very concerned with panning – dramatic panning round the head and in all kinds of trajectories. (This was done with ambisonics and vector surround panning systems). Now, perhaps because of the desire for *stasis* when sound sources move it is usually in repetitive ways, embedded in the texture rather than to be sound objects moving through space. Panning must happen extremely slowly or so fast that it becomes another vibration.

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[117] Varèse, *Poeme Electronique*, compact disc.
[118] Stockhausen, *Gruppen,* compact disc.
[119] Michael Kurtz, *Stockhausen : A Biography,* Richard Toop (trans.) (London ; Boston: Faber and Faber, 1992), 80.

2.7 Emulating electronic or analogue effects

A common technique when working with computer music, tape or record player, is to bend or warp the playback speed. There is a whole universe of strange and wonderful sounds in the small accelerations, slow-downs, double speed, half speed and extreme edges of fast and slow. Think for example of tape as it wobbles right at the beginning acceleration in starting to play. There's a funny short pitch bend and speed up and then the normal sound starts to happen. Or extreme slow motion: the wonderful artifacts, grains, rumbles, hiss and bass that are revealed in even the most commercial tracks. These can take on a completely otherworldly, underwater or alien outer space like quality. I have a long interest in glitch, error, failure and artifacts of technology as input for 'chance' influenced new ideas in music.

The macro motives in *String Quartet No 1* intentionally have an effect of being exaggerated, slowed down and seem as a result introspective. Also the often extremely soft levels expose the 'ugly' surface sounds of the bowing – scratchy, noisy, airy sounds of friction between hairs and strings. Thus surface sounds become a prominent feature. Whilst writing this piece, lots of riot- and occupy movement videos made the rounds, with a strong effect of revolution, violence and protest in my subconscious mind/mood. Glissandi (especially ones long in duration) remind me of sirens: the loud, penetrating howling sound made by a machine. From the sounds of second world war sirens captured on tape and film recordings, to the neighborhood ambulances and fire trucks, to the home alarms and car alarms I grew up with in my native South Africa: a hollow, intrusive, loud, uneasy sound. (When used in a hip-hop or techno context ironically the exact same sound has a joyous quality.) In *String Quartet No.1* the glissandi patterns are to sound like the last remains of sirens buried deeply in space-time and perceived from a point much later than this century.

Chapter Three: Fata Morgana

3.1. Introduction

Fata Morgana (2015) is a piece in two parts for voice(s), tape, percussion and spatial effects.

A fata morgana is an optical illusion seen above the horizon can be seen on land or at sea, in this case I imagine it to be in the desert. Subjective imagery going on in my mind whilst working as that of falling in dreams, of being paralyzed in dreams, travelling vast distances with the eye in an empty desert landscape, euphoria and even falling into a coma.

A horizon is the furthest line on the landscape that the eye can reach. It is in itself unreachable, a place where opposites (land and sky or water and sky) forever try to meet each other, a place where light disappears and reappears. The mirage in this case is the magician (or the mind) producing imagery – morphing, diffusing, and shape-shifting. Brain and body, the mind versus the stimuli. Which is which?

The two parts are named after Bridget Riley's Op Art paintings *Loss* (1964) and *Arrest 3* (1965). Later in this chapter follows a discussion on why her work is such an inspiration for this piece as well as for *Drift, Gala and Mutation 2*.

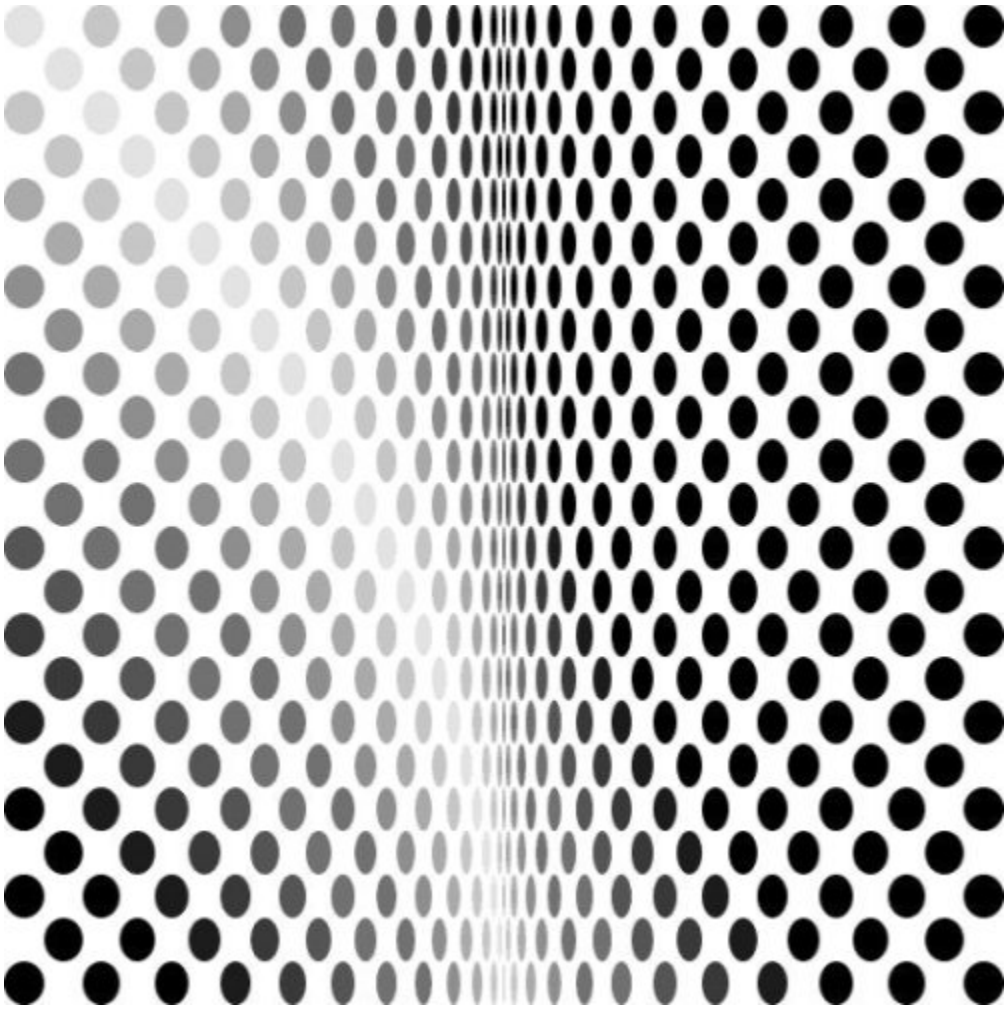

Figure 17: *Loss* (1964) by Bridget Riley.[120]

[120] Bridget Riley, *Loss* (WIKIART Visual Art Encyclopedia, 1964).

Figure 14: *Arrest 3* (1965) by Bridget Riley.[121]

Similar to the hand painted optical illusions (or distortions) in Riley's abstract expressionist Op Art paintings, *Fata Morgana* revolves around an auditory illusion as main material. Variations of the Shepard tone illusion of ever rising or falling pitches are used in deliberately imperfect or shifting repetitions and variations. In *Loss* loose glissandi curves are used in a foreground manner and is treated in an almost a fugue-like fashion with inversions, reflections, mirrors and transpositions until it finally combines into a single articulated instance of the Shepard tone motive only to crumble again and recombine in other kinds of repetitive pitch curves, lines and dots. In *Arrest 3,* I use the Shepard illusion repetitively as a tiling or tessellation pattern to create an immense background

[121] Bridget Riley, *Arrest 3* (WIKIART Visual Art Encyclopedia, 1965).

against which I position minimal foreground musical gestures.

Loss is written for 10 voices and computer control of virtual acoustics and spatial effects. *Arrest 3* is written for 16 voices, percussion and again computer effects. They work well as individual pieces too but since they have such a strong resemblance to each other, they also complete each other in an interesting way: the same musical gestures are presented almost as if at different distances: *Loss* is like a close-up view in which motives are focused and detailed, with clear structures. It ends in a transitional state with new variations of the material sparsely spread out against softer echoes of the older material in the background. In *Arrest 3* the same material is presented larger and at a blurry distance, a continuously growing sublime mass of sound. One could say *Loss* is the tree and *Arrest 3* the forest.

3.2. Space

The spatiality is a major element of the work. The ideal setting is a huge cathedral but virtual acoustics can also be added via computer to create a similar acoustic setting and extra large reverberance.

In *Arrest 3,* delay effects multiply all the voices that sing the Shepard tone material to create a drastic difference in scale and spatial effect between *Loss* and *Arrest 3*. These voices are arranged into 4 sub-groups, each assigned to 4 unique delay effects set at delay times of 500ms, 1000ms, 1500ms and 2000ms. So in total there are 16 extra 'virtual' voices. These delay tracks feature at varying levels, slightly softer than the main voices but they swell and fade like waves at their own tempo to really extend and elongate the existing voices.

A series of sample/freeze/reverb effects are used over the contrasting voices that sing long tones and sustain selected tones far beyond human capability into long drone pitches. The transition to the sampled drone is extremely smooth and sounds natural in the context, giving the voice super human ability. These droned notes add to the already growing spectral cloud. A second series of sample/freeze/reverb effects are used over the total mix. The result is that of continuous expansion both vertically via the illusion of continuous rising as well as in the overall timbre. The reverb effects function similar to a feedback mechanism, each time the processed reverbed sound is sampled back into itself so that this new combined signal is in turn processed.

Tape parts are provided for each voice and effect so that *Fata Morgana* can also be performed by solo singer with the tape parts making up the missing voices. In this case, detailed instructions are provided for the loudspeaker set-up and spatial execution of tape playback.

3.2. Auditory Illusion and similarities to Op Art

The basic motives for *Fata Morgana* is based on an auditory illusion called the Shepard's tone. The psychologist Roger Shepard discovered it in 1964. He demonstrated the effect with a 2-octave hexatonic scale that is repeated. The illusion of an infinite loop is created by 'sneaking' in a replica or 'reflection' of the same scale transposed an octave lower. I use the word 'sneak' because the octave below fades in from nothing. Similarly an octave above fades out exactly opposite to the one below as can be seen in Fig. 5. The result is that the tones seem to rise forever.

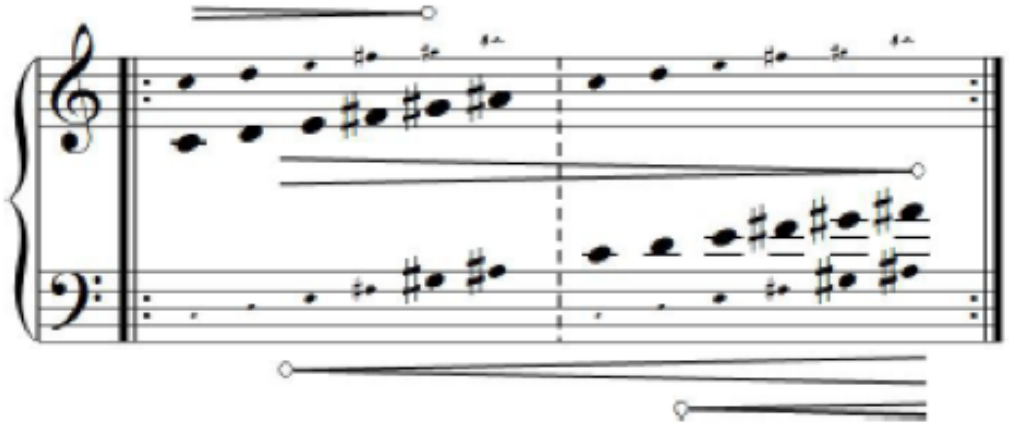

Figure 19: Infinite looping of a hexatonic scale with its own 'reflection' in different shades of loudness [based on Shepard 1964; commented and explained in Hofstadter 1979:712-714].[122]

The effect of pitches sounding as if they are forever rising or falling appropriately features in Douglas Hofstadter's book *Gödel, Escher, Bach* where it is being compared to the famous Escher staircase drawings, where a twist in visual perspective, tricks the eye to make the impossible seem possible.[123]

However, similar to the way Riley paints optical illusions by hand and deliberately leaves her individual human touch on her paintings, I break away from the exact Shepard tone by varying the pitches, durations and entrance points. I do not stick to using octave intervals for the different layers but vary the start and end pitches dramatically. Also the fact that the motives are glissandi as opposed to exact notes, imply that in practicality the exact pitch lines will vary with each singer and each iteration. So the shifting patterns are far more complex and the basic illusion is not

[122] Gabriel Pareyon, ed. *On Musical Self-Similarity - Intersemiosis as Synecdoche and Analogy*, vol. 13, Approaches to Musical Semiotics (Finland: The International Semiotics Institute • Imatra (ISI), 2011), 412.
[123] Douglas R. Hofstadter, *Godel, Escher, Bach: An Eternal Golden Braid* (Basic Books, Inc., 1979), 712-14.

at all perfect. Nevertheless there exist a very strong sense of elongated upward movement that creates an even better effect than I could have imagined.

Jean-Claude Risset created the first computer synthesized glissandi version of the Shepard scale (called the Shepard-Risset glissando) so that the tone appears to rise (or descend) smoothly and used it in *Computer Suite from Little Boy* (1968)[124] and *Mutations* (1969)[125]. Is was whilst working on these two pieces that Risset made huge contributions to computer music with his synthesis techniques using the famous Music V program whilst working with Max Matthews at Bell Labs (with the most powerful computers of the time).

Computer Suite from Little Boy consists of three space-travel-sounding movements, *Flight and Countdown, Fall* and *Contra-Apotheosis.* From 26' to 1"30' *Flight and Countdown* has an extremely slow and low upward Sheppard-Risset glissando that is interrupted by a loud percussive bang and change of material into a jazzy groove. However the glissandi drone remains at softer level in the background and slowly swells again as the groove fades and disappears by 2". By 2"08' a second slightly higher Sheppard-Risset glissando starts with variations and movements around it until 2"49'. Percussive sounds follow again and at 3"30' the lowest Sheppard-Risset glissando fades in from absolutely nothing. There are also constant occurrences of other percussive sounds (with remarkable timbre qualities) that pitch shift in their short lifespans and very fitting to the overall character of the sounds. Also parallel short duration glissandi and Sheppard-Risset glissandi occur in opposite direction. At 3"42 another glissando that sounds like synthetic sucking in of breath (or reversal of direction of motion), with a repetitive ticking sound and another sound similar to a busy signal of a telephone in the background, building up with a sudden forward and higher pitched sweep to end this movement.

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[124] Risset, *Computer Suite From Little Boy*, compact disc.
[125] Risset, *Mutations,* vinyl.

Overall the effect of these rising and falling glissandi motions really has in essence the feeling of 'approach' (or acceleration and deceleration of a machine) over great distance. It really feels to me when listening like I am in a spaceship and the sounds are that of the machine as we accelerate at light speed to zoom in onto a planet and approach landing. Yet only to pull away again in the opposite direction and so forth.

Whilst composing *Loss,* I had a strong sensation of motion, from the very first vocal sound falling out of the sky and accelerating to the ground, with many echoes and variations and fluffy whisking motions up into the air again. Abstract but very human because of the voice. There is also a playful element to these sounds – they are slightly ridiculous and slightly euphoric similar to the spaceship quality from *Little Boy* that is so alien it takes on a comic book 'illustrated' quality. The falling and rising motives in *Fata Morgana* overall and especially *Loss* have a very similar effect to the sounds of 'approach' in *Little Boy*; it is only a lot more human and slower in motion. I am actually quite surprised to discover the strong correlation between *Loss* and *Flight and Countdown*. Also in terms of counter layers and strong similarity of material.

In Stockhausen's *Hymnen* (Region IV)[126] together with the disintegration of the final chord of the Swiss anthem, Stockhausen also uses extremely slow long stretches of electronically synthesized downward spiraling Shepard Tones. Risset's *Fall*[127] predictably starts with a long downward Shepard-Risset glissade for nearly the first 70' and then a second even lower long downward Shepard-Risset glissando follows as next motive and carries on all the way to the end of this second movement. A series of short clock-like ticking pitches fade in and match pitches at key intervals of the downward frequency slide while an airy cloudlike high frequency range Sheppard glissando fades in at the top range of the frequency spectrum.

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[126] Stockhausen, *Hymnen,* compact disc.
[127] Risset, *Computer Suite From Little Boy*, compact disc.

Again there are some strong similarities to my second part *Arrest 3,* except that all the glissandi go upwards and that the scale is much larger in duration.

Risset also created instrumental renditions of this effect via endless scales in the choral piece *Dérives* (1985) (movement III) and in the third movement of *Phases* for orchestra (1988) as well as in *Triptyque* for clarinet and orchestra (1991) and in *Escalas* for orchestra (2001) but I am unable to find any recordings of these pieces online or in shops. One could say that similar to Feldman, Risset is also a materialist as he makes it clear that one of the most important aspects of his music is that it is perception based:

> Structures can often be defined in a rigorous, objective way, for instance in terms of mathematical descriptions. However what counts in art is not the objective structure -per se - but the structure in us, as we experience it through our senses.[128]

This is a very wise and sobering observation. Especially when it comes to using mathematical ideas, it can easily happen to be blinded by the 'objective' conceptual or cognitive vision, but most important for a musical effect to succeed is that it must be perceivable. James Tenney who made an in depth study of psychoacoustics and aural perception shared this important view. Risset also says the following about illusions: "As Purkinje said, illusions are errors of the senses but truths of perception".[129]

In describing her development as a painter and turning to her minimalist Op Art way of working, Bridget Riley said the following:

> I decided that rather than trying to create abstract forms from landscape or the human figure, I would do what Mondrian had done and start with the

[128] Risset, *The Perception of Musical Sound - Computer Music, Why?*
[129] *Ibid.*

> basic elements of form: the line, the rectangle, the plane. I found that when I distorted them they became active. […] The curve is frozen movement.[130]

The result it that her works have no center, is 'essentially formless'[131] but what amazes me is that the lines and curves have so much motion: I see vibration, acceleration, speed, deceleration and infinity. Op Art is a form of abstract geometric art that generates physical sensations in the viewer and thereby reveal some aspects of how vision functions. Patterns and lines are placed in such a way that foreground and background are in tension. Riley herself has described her paintings as 'high-voltage'.[132]

What draws me to it is the inevitable physical response I have when looking at it. My eyes don't jump or scan over the canvas. My eyes *vibrate.* This effect is a great influence on the difference tone pieces *Drift, Gala* and *Mutation 2* described later on.

One can observe resemblances between *Fata Morgana* and the mentioned Riley paintings. I too use a perceptual illusion as basic material. I also deviate by hand from the exact execution of the curves (similar to the way Riley insists to paint by hand and introduce her own human fluctuations to the curves). I use the auditory illusion to elongate the musical gestures – in fact spread it over the entire time canvas as a kind of 'background' against which other motives move in opposite directions, or single notes or note clusters are positioned like stationary rocks in a moving ocean.

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[130] Mark Hudson, 'Bridget Riley: How I Got My Curves Back' (http://www.telegraph.co.uk/culture/art/art-features/11674111/bridget-riley-interview.html, 15 January 2016).
[131] Alastair Sooke, Bridget Riley, 'National Gallery, Review' (http://www.telegraph.co.uk/culture/art/art-reviews/9325107/Bridget-Riley-Works-1960-1966-review.html, 11 January 2016).
[132] *Ibid.*

3.3. Process

The process for creating *Fata Morgana*[133] started via a very hands-on trial and error studio session thanks to vocalist Michelle O'Rourke who tried out roughly sketched out glissandi patterns that were all variations based on the Shepard tone illusion. Having such a clear idea of the sound right from the beginning is a very effective working process that I would give preference to whenever possible.

These recordings were used to create a tape part consisting of 7 layers that compliments the solo voice. After the premiere of *Relativity for Mezzo-soprano voice and Tape* (2012), I really wanted to develop the material further into a larger format and thus it became the groundwork for *Fata Morgana.*

I wrote out each tape part completely and added voices so that it could also be possible for 8 - 10 singers to perform *Loss* acapella. Upon completion of *Loss* it was clear that the material had a lot more potential. Thus *Arrest 3* was created.

Risset describes that in computer music, with the advent of recording, causality became different to sounds produced by acoustical instruments – time becomes an element that can be symmetrically treated i.e. exact reversal of sound. Allowing him to renovate the sound and not just the syntax (as with instrumental music). Sound now escapes causality.[134] This is certainly an element that I am exploiting in my work so far. One can perfectly mirror certain sonic events especially when working with tape. Upon transcribing the tape parts for live voices, the structural effects remain (even if reversal of material will not be exact, it is a strong influence

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[133] I first named it *Relativity* after the Escher painting by that title that has three, but whilst working on the material the imagery of Riley's work came to mind and as I searched through online images of her works, the two mentioned works seemed to vibrate in exactly the right way.

[134] Jean-Claude Risset, *Music Is Meant to Be Heard: Perception Is Central in (My) Computer Music* (Laboratoire de Mécanique et d'Acoustique, France (ONLINE): CIRMMT, 2011).

on the structure). See Fig. 21 for fragments that resemble smaller fragments, which are in turn reversed and layered over the original at key points. Glissandi figures lend themselves particularly well for mirroring of motives: there are no prominent attacks or decays but instead the main characteristic of each motive is a pitch curve. A lot of structural mirroring and echo occurs and is clearly audible.

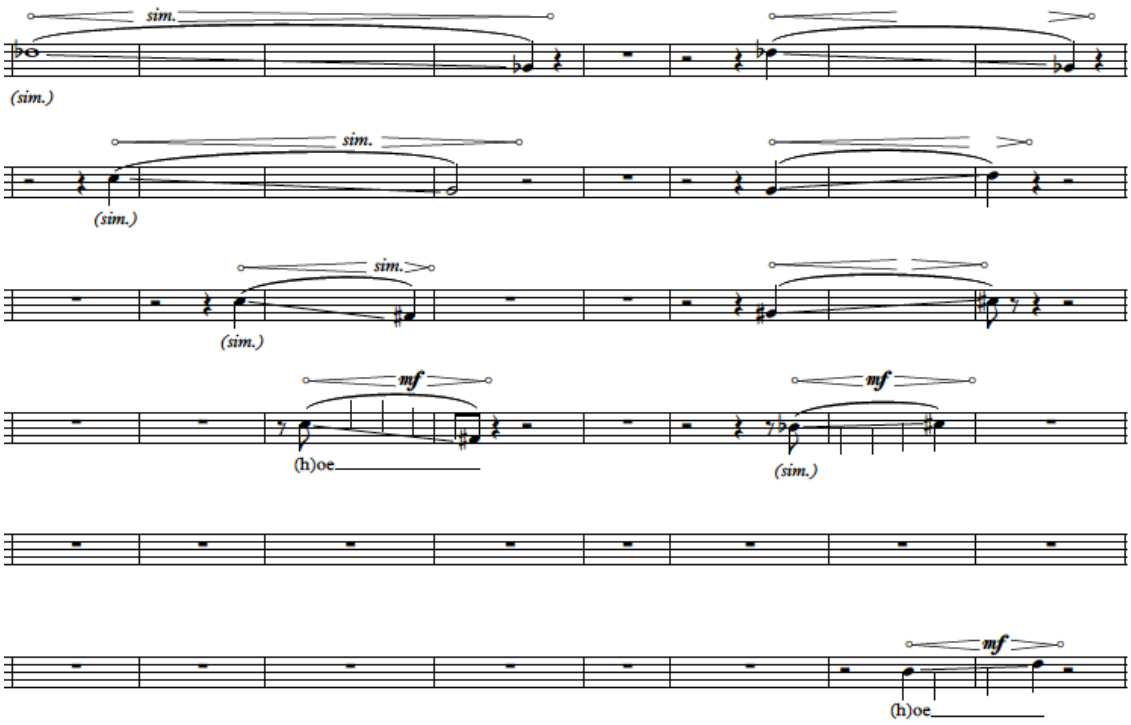

Figure 20: *Fata Morgana – Loss,* Bars 7-14. Mirroring in the form of pitch retrograde, diminution and repetition amongst voices can be seen.

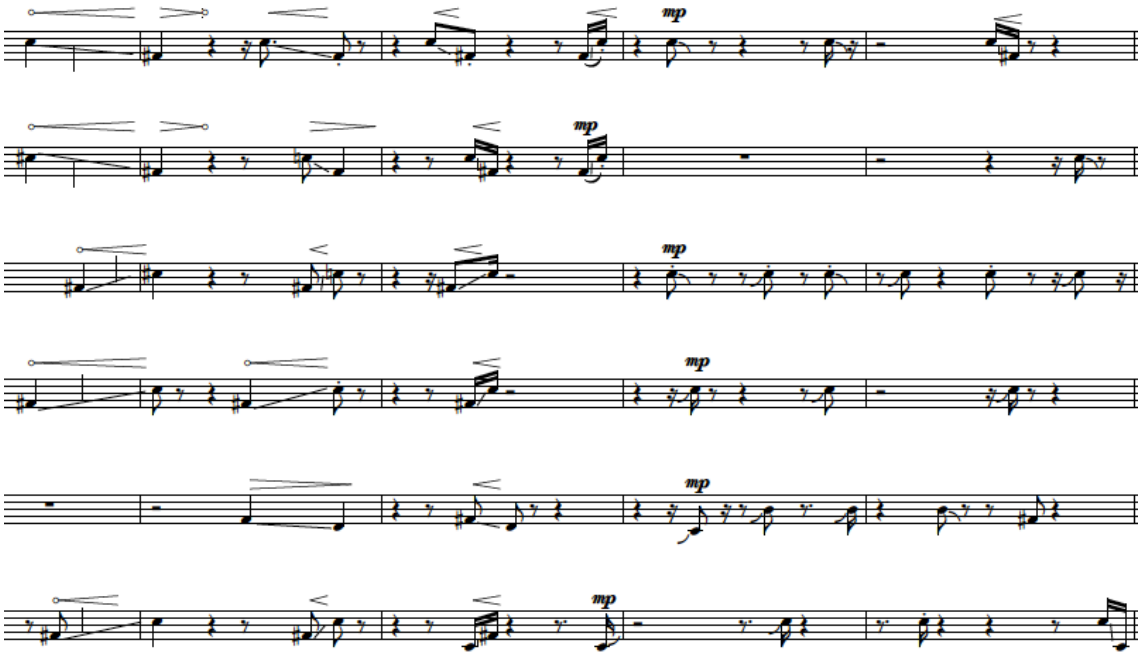

Figure 21: *Fata Morgana – Loss,* Bars 87-91. Mirroring in the form of pitch retrograde, diminution and repetition amongst voices can be seen.

3.4. Timbre, Spectral elements and form

James Tenney also had an interest in the Shepard-Risset glissandi as can be heard very obviously in the electro-acoustic piece *Anne (rising)*[135] and the orchestrated version *For 12 Strings (rising)* in *1971.* Not surprising since Tenney also spend some time at the infamous Bell Labs at the same time that cognitive psychologist Roger Shepard was there and working on this phenomena.

For 12 Strings (rising) was written for two contrabasses, three cellos, three violas, and four violins.

[135] Tenney, *For Ann (Rising)*, compact disc.

> In this work each instrument executes an ostinato consisting of an upwards glissade, but the instrumental parts are carefully dovetailed in both pitch and dynamic to give the impression of a collection of overlapping tones smoothly rising more than five octaves from F1 to A6 and separated by intervals of a tempered minor sixth. […]
>
> *For 12 Strings (rising),* while it addresses a specific phenomenon apparently not explored in other spectralist instrumental works, clearly bears many of the principal earmarks of spectral music as it is described in the literature (cf. Fineberg 2000). It is, for instance, a deliberate orchestration of a particular spectrum, undertaken with attention to phenomenology rather than semantics, and exhibits a process-form and expanded temporal scale that facilitate exploration of the music as a phenomenon. Furthermore, like many other spectral compositions, it is an orchestration of electro-acoustic source material.[136]

Similarly, for large sections of *Arrest 3,* each voice executes an ostinato consisting of an upwards glissade and similarly the different voices are dovetailed in both pitch and dynamic to overlap the individual slides into a unity of what I like to call musical tessellations[137]. Similarly this allows me to extend a single vocal gesture to a massive proportion of 3 octaves. Similarly I break away from the Sheppard octave spacing but instead position them according to pitch intervals that my ear - favors in context of the overall piece.

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[136] R. Wannamaker, *North American Spectralism: The Music of James Tenney* (Istanbul, Turkey, 2007).

[137] 'A tessellation of a flat surface is the tiling of a plane using one or more geometric shapes, called tiles, with no overlaps and no gaps. In mathematics, tessellations can be generalized to higher dimensions and a variety of geometries.
A periodic tiling has a repeating pattern' (https://en.wikipedia.org/wiki/Tessellation, 1 March 2015).

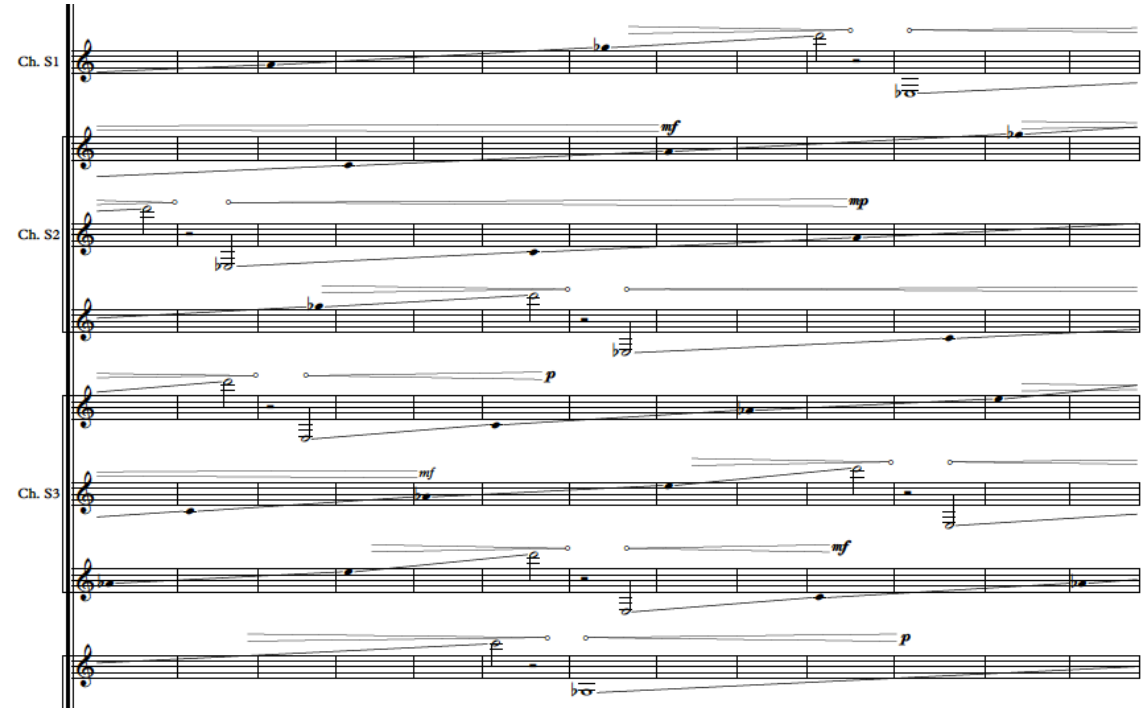

Figure 22: *Fata Morgana – Loss,* Bars 55-67*.* Dovetailing upwards glissade.

Different from *For 12 Strings (rising),* none of my tessellations are exact, but are done by hand and ear, again similar to the Riley paintings, and thus a major amount of small variations and deviations give it a dense spectral complexity and overall character.

Similar to *For 12 Strings (rising), Arrest 3* is an orchestration of electro-acoustic source material. I also use process-form and expanded temporal scale that facilitate exploration of the music as a phenomenon. However, I interrupt this material at key moments with a second type of material that is similar to Varèse's 'static pitch fields'[138]. Extreme repetition of notes are staggered between different voices and extended via delay units. These pedal point patterns are sustained throughout entire sections, with glissandi departing from each repeated note that in turn create dense textures around the repeated pitch fields.

[138] Cornicello, 'Timbral Organization in Tristan Murail's *Désintégrations and Rituals*', 16.

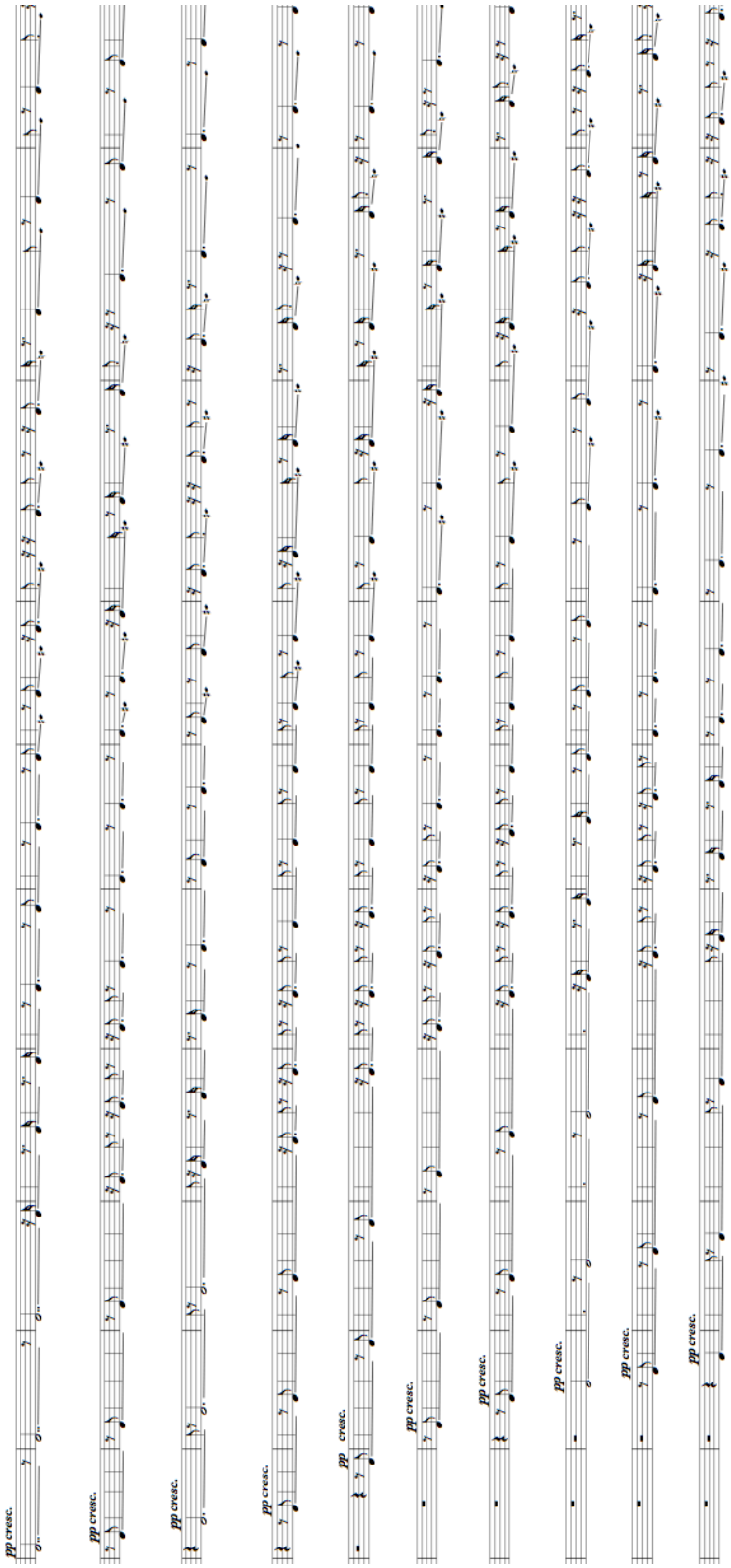

Figure 23: *Fata Morgana – Arrest 3*, Bars 409-17. Pitch fields, staggered note entries and expanding glissade 'tails'.

These fast repeated phrases situated around a single pitch, staggered instrumental entrances and the avoidance of pulse can be seen as micropolyphonic techniques such as described by Ligeti[139]. The resulting texture and sound mass bare strong resemblances to *Atmosphères* (1961)[140] with a similar existential overall quality. However, an important added textural detail is that these short repetitive glissade, each time slide a micro pitch increment further. So the pitch field's spectrum expands or bends downwards over time. This has a very subtle effect of pitch bend reminiscent of Scelsi's music except in this case it's an entire sound mass that bends, so it's not an accurate sound, but rather a cloud that 'melts'. In total there are 8 of these pitch fields and 3 Shepard's tone sections.

Arrest 3 – Macro form:
Bars 1-184: Shepard's tone tessellation
Bars 185-199: D downward glissade pitch field occurs in 4 voices
Bars 203-220: D downward glissade pitch field occurs in 10 voices
Bars 225-240: D downward glissade pitch field occurs in 10 voices
Bars 243-260: D downward glissade pitch field occurs in 10 voices
Bar 243: Delay effects turned on from here till end.
Bars 265-384: Shepard's tone tessellation (voices vary).
Bars 359-408: D downward glissade pitch field occurs in 4 voices
Bars 409-424: D downward glissade pitch field occurs in 10 voices
Bars 431-446: D downward glissade pitch field occurs in 10 voices
Bars 449-466: D downward glissade pitch field occurs in 10 voices
Bar 470-536 (end): Shepard's tone tessellation

A third type of material consists of pointillist single notes or note clusters that accentuate particular spectral moments. In the low end, bell plates and tubular bells are used extremely sparsely as punctuation between large sections. Because everything else is constantly shifting (in terms of pitch) the only tonal markers

[139] Griffiths, *Modern Music and After*.
[140] Ligeti, *Atmosphères*, compact disc.

and ‘stillness’ are these pointillist clusters in the top layer and bass notes in the percussion as well as the main D of the pitch fields. The percussion pitches are Tubular Bells: C4, E4, G4 and Bell Plates: G2, G#2, C3, E3, G3. So there is in the end hardly any dissonance to be found, except for masses of dovetailed glissandi. I would like to attempt a similar piece for full orchestra next.

Chapter Four: Haute Rorschach

4.1 Introduction

This piece is inspired by the well-known inkblot personality test designed by Swiss psychiatrist Herman Rorschach in the 1920s which consists of 10 cards, each with a different symmetrical inkblot patterns to which subjects respond.[141]

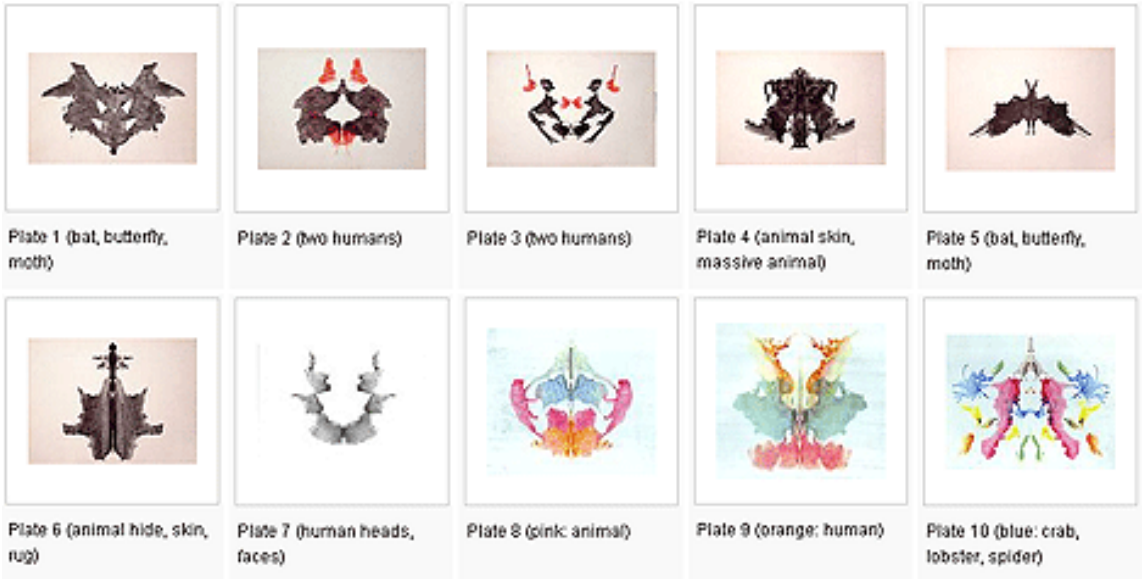

Figure 24: Basic 10 inkblot images of Rorschach test.[142]

To create an inkblot one drips or paints with ink on one side of a piece of paper and fold it over to get the reversed mirror image on the opposite side. Via the

[141] 'Hermann Rorschach,' *Encyclopedia of World Biography* 2004, (http://www.encyclopedia.com/doc/1G2-3404705566.html, 25 April 2016).
[142] Hermann Rorschach, *Rorschach Test – Psychodiagnostic Plates* (Hogrefe, 1927).

subject's response to the image, things about the subject's psyche are 'revealed' as if looking into a mirror of the psyche. The test is rather controversial.
Departing from this imagery, I wanted to create a piece in which each motive is reversed in this fashion. But then go even further to use this concept of folding and mirroring as a growth process.

4.2 Form

The overall form and structure of the piece is that of exact and broken mirroring or symmetry of motives. In the start symmetries are clearly perceivable. A motive happens and then reverses. Time folds back and forward on itself in different tempos as a type of memory game. Combined motives form larger building blocks that also occur and then retrograde. As the piece progresses patterns become more complex, symmetries are progressively obscured until the final material gets 'stuck' in a repetitive loop.

Each small musical motive happens, next is echoed in reverse (fig). Next the segment plus its mirror becomes a larger phrase (new motive) that again is echoed in reverse (fig). Sections are notated by alphabetical numbers where the mirror of **a** is !**a.** (In coding languages the exclamation mark means 'not' and I have borrowed that element for notating the inversions of motives). **!a2** is the mirror of **a2**.

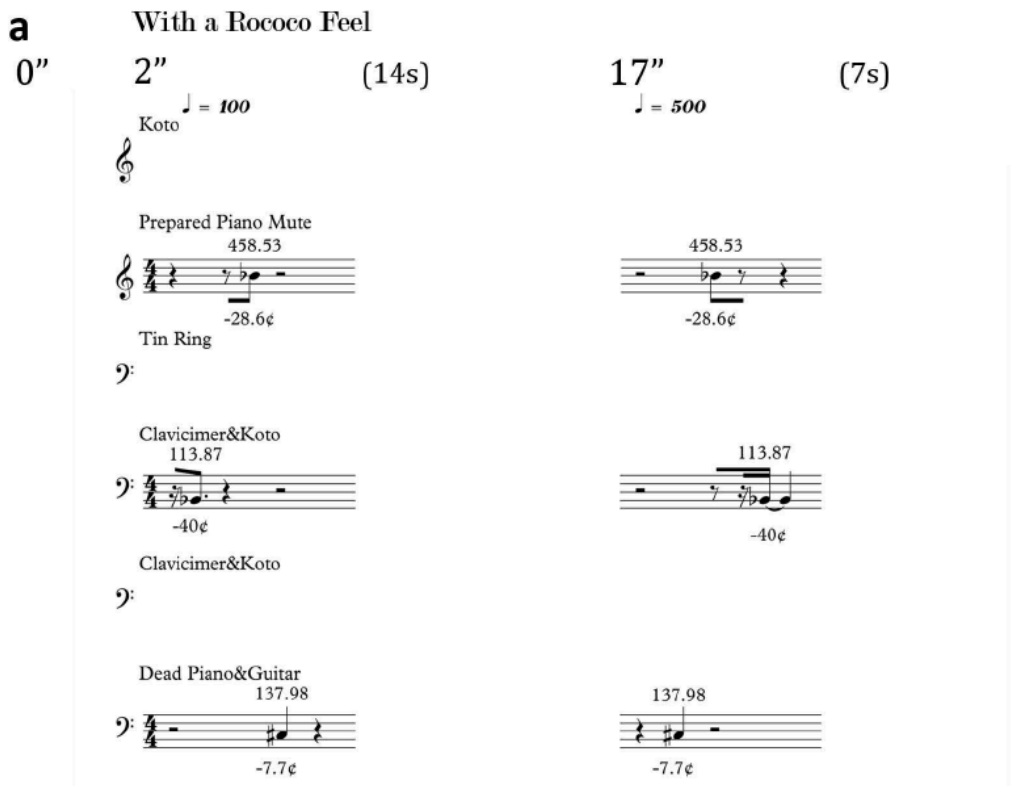

Figure 25: *Haute Rorschach* – section **a**. The first motive happens and repeats in retrograde after a 14sec rest.

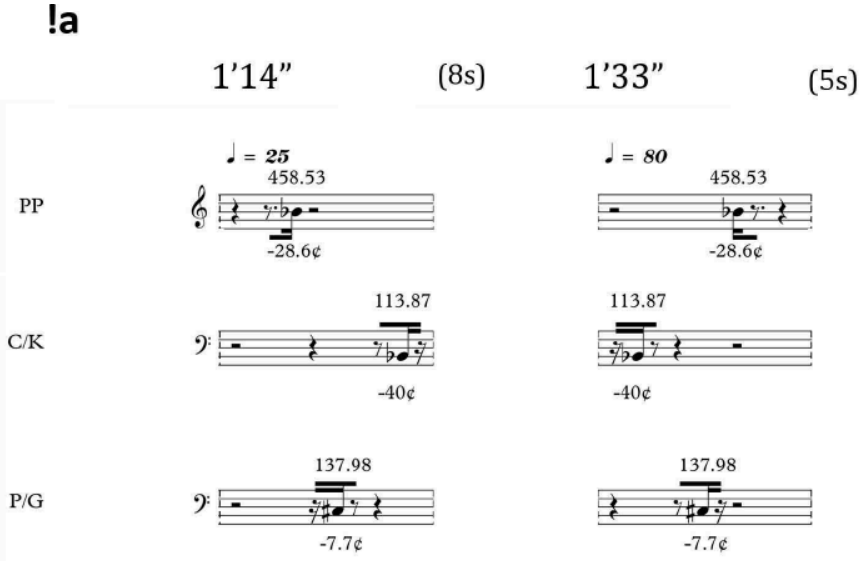

Figure 26: *Haute Rorschach* - !**a** is the mirror (retrograde) of **a** (Fig. 25).

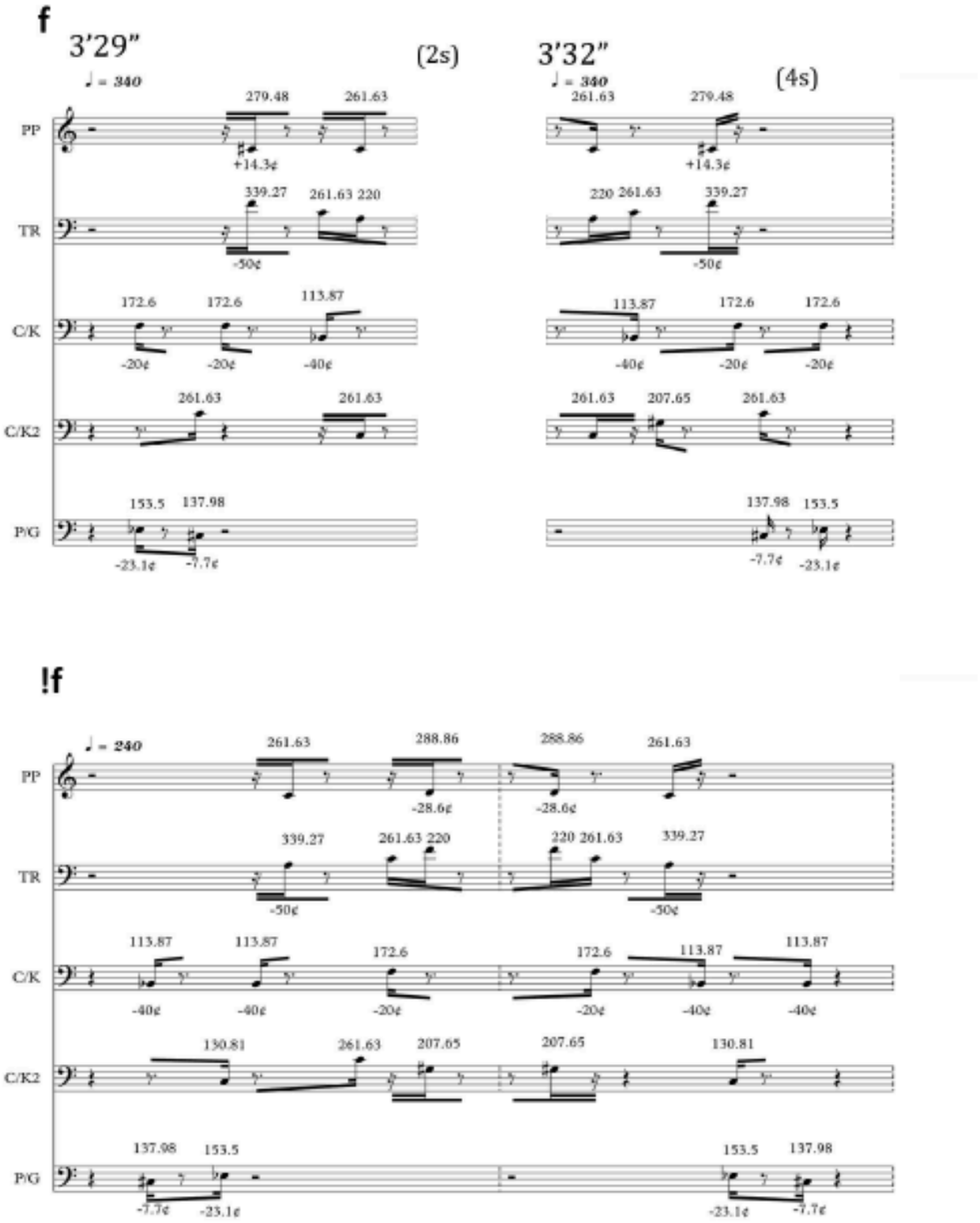

Figure 27: *Haute Rorschach* - **f** and it's retrograde mirror **!f**

4.3 Tuning – Fibonacci re-appropriated – 3-Tet, 5-Tet, 8-Tet…34-Tet

Haute Rorschach is situated inside a rather dense 'harmonic' (subtly dissonant) color world. It consists of 6 scales stacked on top of each other. Each layer correlates to an individual instrument in the piece. Each scale is made up from an individual temperament.[143] These are derived by using the Fibonacci sequence and dividing the octave into according proportions:

Scale 6 (Koto) = an octave divided into 34 equal intervals.
Scale 5 (Prepared Piano) = an octave divided into 21 equal intervals.
Scale 4 (Tin Ring) = an octave divided into 13 equal intervals.
Scale 3 (Clavicimer/Koto combination) = an octave divided into 8 equal intervals.
Scale 2 (Clavi/Koto2 with different characteristics) = an octave divided into 5 equal intervals.
Scale 1 (Dead Piano/Guitar) = an octave divided into 3 equal intervals (major thirds).

From these temperaments only a few pitches are selected for each scale. The criteria are that these scales must first of all sound good in themselves, but they must also sound good in relation to all the other scales combined.

[143] Please see *Appendix A* at the end of this document for a complete list of frequency values of each temperament and *Appendix B* for a technical description of my Max/MSP tuning patch. This patch includes functions to calculate any temperament, a converter of frequencies to midi notes plus pitch bend values, a router patch for real-time routing between software such as Sibelius and Ableton Live, as well as a frequency tracker that records all played frequencies in a score.

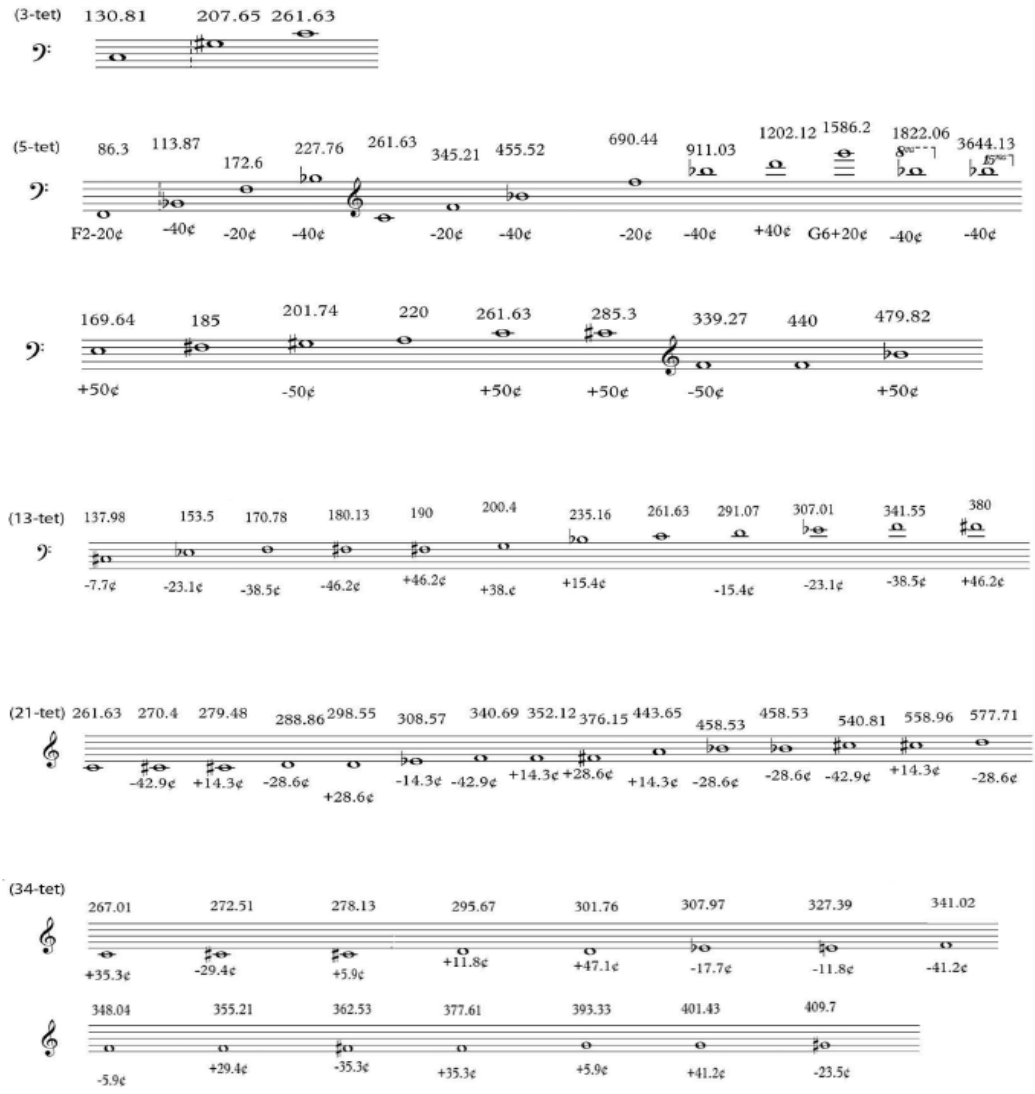

Figure 28: Scales selected for *Haute Rorschach*

4.4 Meta tonality

The initial incentive for doing this was to extend the 'mirroring' space vertically. To create a tuning meta space in which a musical motive shrinks and expands as it is echoed between different voices over different scale, as can be seen in the following image:

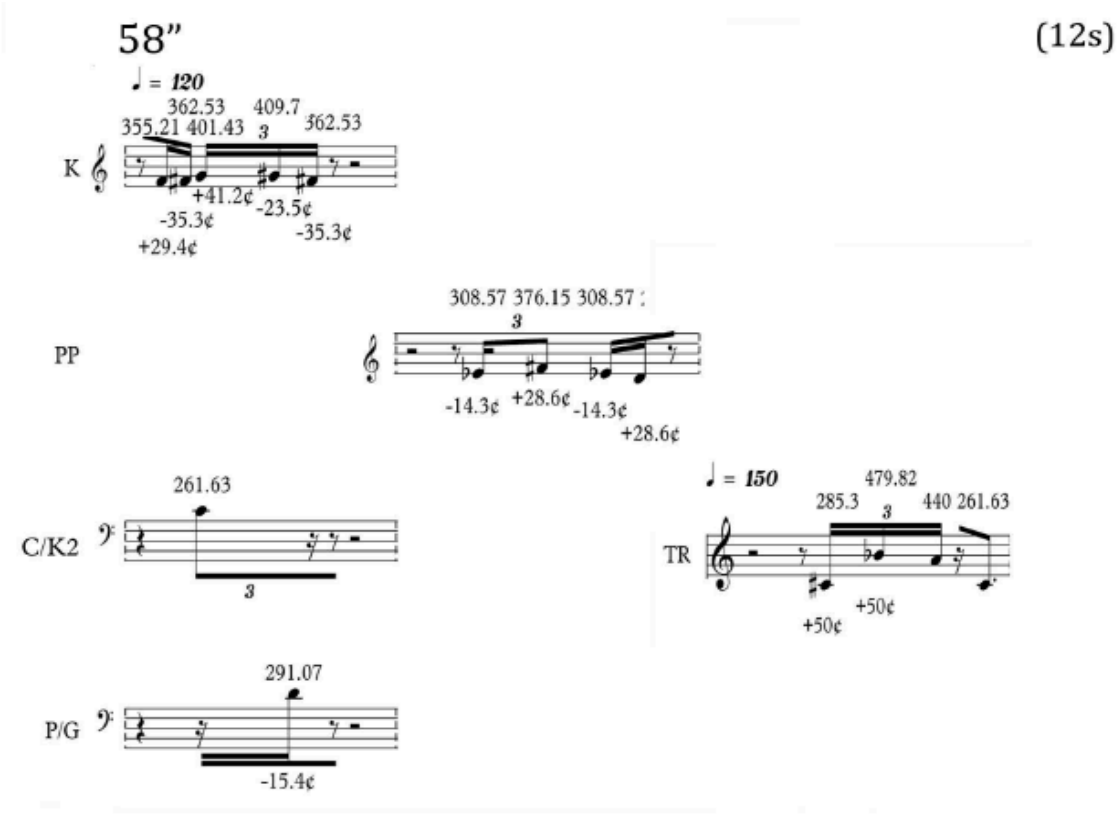

Figure 29: A motive's intervals expand vertically as it is echoed from the Koto 34-tet scale (top staff) to the Prepared Piano 21-tet scale (second staff) to the Clavicimer/Koto 5-tet scale (third staff).

One way to consider the intervals between the scales are how they function vertically between the different tuning systems. One can argue that this piece

exists in a meta tuning system. Integrity is maintained for each tuning: each scale has unique instruments assigned to it. Thus as self similar patterns echo amongst instruments, the same rhythmic and/or melodic pattern transforms dramatically across scales: a pattern in scale 6 may cover the smallest micro distance, whilst the same pattern in scale 1 may cover more than an octave.
Over time, as the piece progresses, a sense of a deeper order is clearly present. There is nothing random sounding. The dissonance is also extremely subtle.

This idea of meta tuning is very new and I haven't come across another composer who works like this. For future pieces I would experiment with making the distinctions between tunings more obvious by using more diverse instruments.

Again, my motivation for choosing instruments (all plucked strings) was to achieve an extremely subtle effect and high level of self-similarity. Adding a bit more explicit pattern repetition amongst voices and adding more timbre differentiation (diversify instrumentation) may be a rather thrilling experience for a next piece.

4.5 The Importance of Hidden Things (Zen Garden principle)

The most important 'hidden' layer of the piece is how it speeds up and slows down in a contorting way. As if watching a movie in fast forward, then abruptly stopping, slow motion, rewind etc. The changes are so frantic that tempo numbers are used to indicate the tempo range.

Here I find again resonance with another Feldman description where he speaks about his approach to his early graph music (*Intersection)*[144] and inspired by conversations by abstract painters about when a work of art is finished. He says that the main thing he learned was to ask questions, to ask, "What's needed?" and controlling time: "To me time was the distance, metaphorically, between a green light and a red light. It was like traffic, it was a control. So I always controlled the time, but I didn't control the notes".[145]

He also says the same thing in another way:

> I'm listening to a kind of symbolic harmony; I'm listening to what I feel the acoustical reality is, how much it takes to really hear it. Also, silence is my substitute for counterpoint. It's nothing against something. The degrees of nothing against something. It's a real thing, it's a breathing thing.[146]

See Fig. 30 for an example of a dramatic tempo change, from 460bpm to 100bpm.

The other important time element is the use of 'gaps' or silences that are precisely notated. For example, the piece starts with 2 seconds of silence, and then there is 2 seconds of sound, then again a 14 second long notated silence (Fig. 25).

The silences however are rather busy. The piece is performed against a tape part backdrop of industrial noise and deconstructed dub-like sounds that move according to a separate tempo and rhythmic identity. The intension is to create a rhythmic and textural disparity of extreme opposites that becomes in itself another kind of meta space in between the instrumental playing and the electronic sounds.

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[144] Morton Feldman, *Intersection I-IV,* compact disc.
[145] Feldman, *Give My Regards to Eigth Street,* 173.
[146] *Ibid.,* 181.

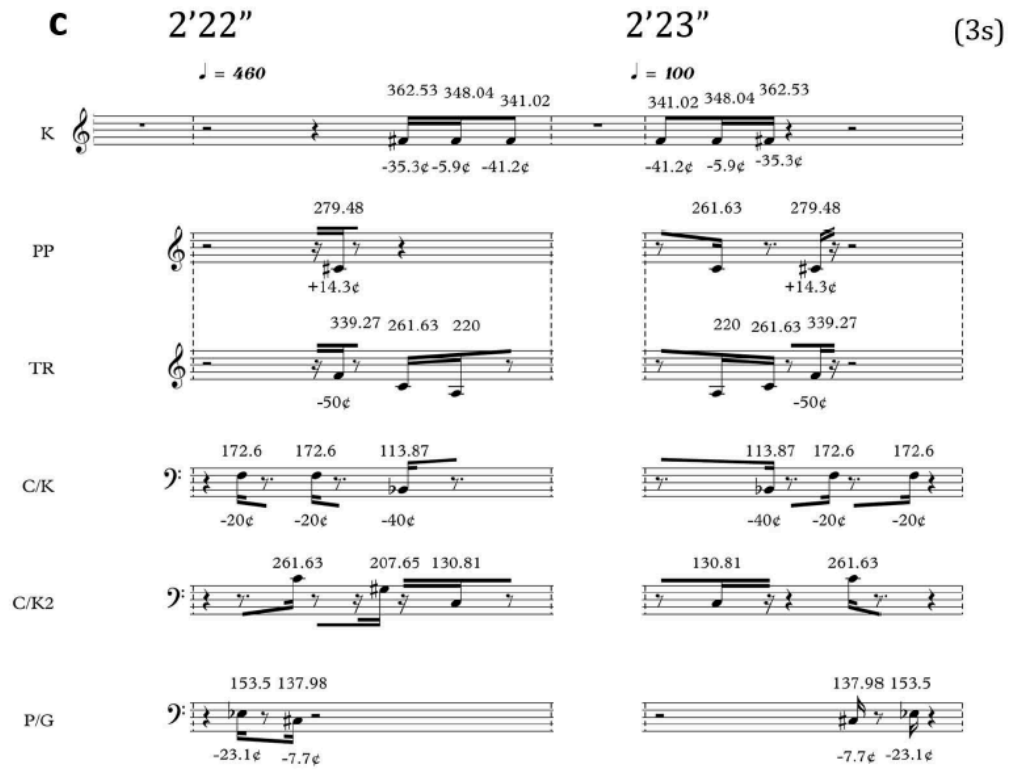

Figure 30: Tempo changes are used throughout *Haute Rorschach.*

4.6 Glitch/embracing error

In *Haute Rorschach* small errors and artefacts found in the 'silence' between notes found in the test recordings made of the instrumental string parts are amplified to the extreme (and I really mean extreme for example +90dB). They are then pitch shifted, distorted or manipulated to create extreme noise bursts or dub/glitch like dirt as electronic counterpart material for the main 'clean' and harmonious plucked string melodic material.

The noise bursts function as a kind of call-and-response to the virtual acoustic space created for the piece. Because the noise fills out a wide frequency spectrum it is very effective in activating beautiful reverberations (with long delay times) that cast a kind of halo around the string sounds. In fact I like to think of noise as one would think of light and exposure in film. One can completely overexpose the image to minimize and accentuate beautiful 'unnatural' shapes or lines in the image or one can use a vast array of different temperatures – yellow, white light to create various shadows and moods. Most importantly it accents the dark to be even darker. My interest is mostly to use noise as a way to enhance *silence.* To create space, as a background or secondary element and especially as a 'ping' to accentuate the acoustic space, be it real or virtual or both.

In order to achieve this, reverb layers used for the noise/glitch sounds are carefully shaped by hand (by drawing in envelope curves in the editing software). Extreme detail is of major importance to each moment. For each sound occurrence, careful attention is given to the overall envelope of the reverb including attack, frequency range (via dynamic equalization filtering), sustain and fade out of the reverb. This includes dramatic swells in volume, drastic sudden loudness and also subtle soft moments. Other parameters such as reverb size, delay time, density, scale; loudness of reflections and loudness of diffused level versus dry level are all shaped individually for each sonic event.

4.7 Instrumentation

The suggested instruments for these voices are to be reminiscent of baroque or rococo music: lute, harp, Clavicimer or other similar instruments such as koto, prepared piano (in a way that makes it tinny but not lose the pitch), acoustic guitar or other exotic plucked instruments. Some musical motives are also written

to sound like characteristic ornate rococo style, yet it's always very short and fragmented. As with most of my pieces, it is also indicated that computers, samplers, synthesis, physical modeling can be used by any kind of musician to play each part. As long as the quality of the sounds remains baroque like: this is important to counter the glitch/noise layer.

> 'Noise and beauty might initially seem like opposites, but in combinations, they dismantle the musical frame that used to maintain a healthy distance between the artwork and the outside world'.[147]

Another option is that a computer sends all the data to real mechanized acoustic instruments that have controllable tuners installed as well as trigger/pluck/exciter mechanisms. Konrad Sprenger has developed a unique computer/tuner/actuator mechanism in which he can send tuning and note messages in real time from his computer to the guitar.[148] There is also Richard D James who controls acoustic instruments with his computer. More micro-tunable instruments are appearing. There is for example Geoff Smith's *Fluid Piano*:[149] that is micro-tunable. Obviously the near future presents a rich potential in terms of performing with micro tunings. Perhaps I will still be able to have a robot ensemble perform my pieces in the next decade...

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[147] Demers, *Listening through the Noise,* 104.
[148] Conrad Sprenger, 'About the Computer-Controlled Multi-Channel Electric Guitar' (http://www.konradsprenger.com/solo/, 10 February 2016).
[149] Geoffrey Smith, 'The Fluid Piano' (http://thefluidpiano.com/about.html, 10 February 2016).

Chapter Five: When all memory is gone

5.1. Introduction

When all memory is gone is the only other piece (together with *Haute Rorschach*) in which the notes have audible attacks. The main inspiration here is the sound of the large church bell of the wonderful St. Peter's Basilica in Rome. Hearing it for the first time was another one of those unforgettable audio 'shock' moments in my life. So beautiful and so old: to think about how many times, that same sound has rung out the space of the square and the surrounding Vatican City.

Initially I considered to run a spectrum analysis and develop a piece around these frequencies, but then favored a less literal approach: to create it from memory and imagination. The bell idea morphs and drifts into a slower and slower contemplative drone like spatial exploration. During the composition process I was thinking about what the future holds for human existence and if we as a species will eventually disappear – if so what will remain? Humanity is already collectively and frantically collecting and archiving 'selfies' of every single aspect of our existence. What will become of all this? Will there be a *2001 Space Odyssey* HAL 9000–like[150]artificial intelligence drifting somewhere in space to remember us?

In parallel to the large bell in Rome, a grandfather's clock in a house in South Africa. In a small town in the middle of nowhere, on flat land, with huge skies and dramatic sunsets, clouds, stars. Memories from childhood. Wandering through

[150] Arthur Clarke, 'Hal 9000' (https://en.wikipedia.org/wiki/HAL_9000, 3 March 2016).

the empty house, only the ticking of a grandfather's clock and then finally three strokes of sound.

5.2. Time and space

There is again very little pulse or movement going on at the macro level, except for the slow repetitive microtonal clusters reminiscent of the ticking of a clock or some sort of counter ticking away at a deadly slow pace. The distances between events grow larger and the space also.

Making use this time of only the 34-tet equal temperament, there is a lot of potential to create extremely small intervallic shifts. Similar to the instant of a bell being activated by hammer, each group or cluster of notes start with short attack, medium sustain but then the fade out gets extended in a large reverb's tail (or decay duration). The spatial effect is large – each instrument is assigned to its own reverb effect for more realistic effect. This enables me to equalize the unique frequencies and the way they behave within each reverb to optimal beauty. On some long reverb moments, subtle frequency sweeps are used to morph the sound quality from smooth dark liquid into rougher lighter noisy textures and then with the onset of the next event it is dark, smooth and far again. Added to these individual effects for each track, are also various master reverbs to wash the colors of the total mix in further subtle ways – the result of this is that the overall mix is also blended into a convincing singular space.

5.3. Timbre

One particularly effective strategy to achieve variation in timbre is to shift notes among voices (see fig). Here you can clearly observe how the first pitch in the top voice echoes down into the next voice and the next. In fact all three pitches keep rotating. This happens throughout the piece, also in the bass notes. Each time the 'bell strikes' (each next cluster) the ear can recognize the same pitches, yet the timbre changes are subtle but keeps the overall sound interesting and in motion.

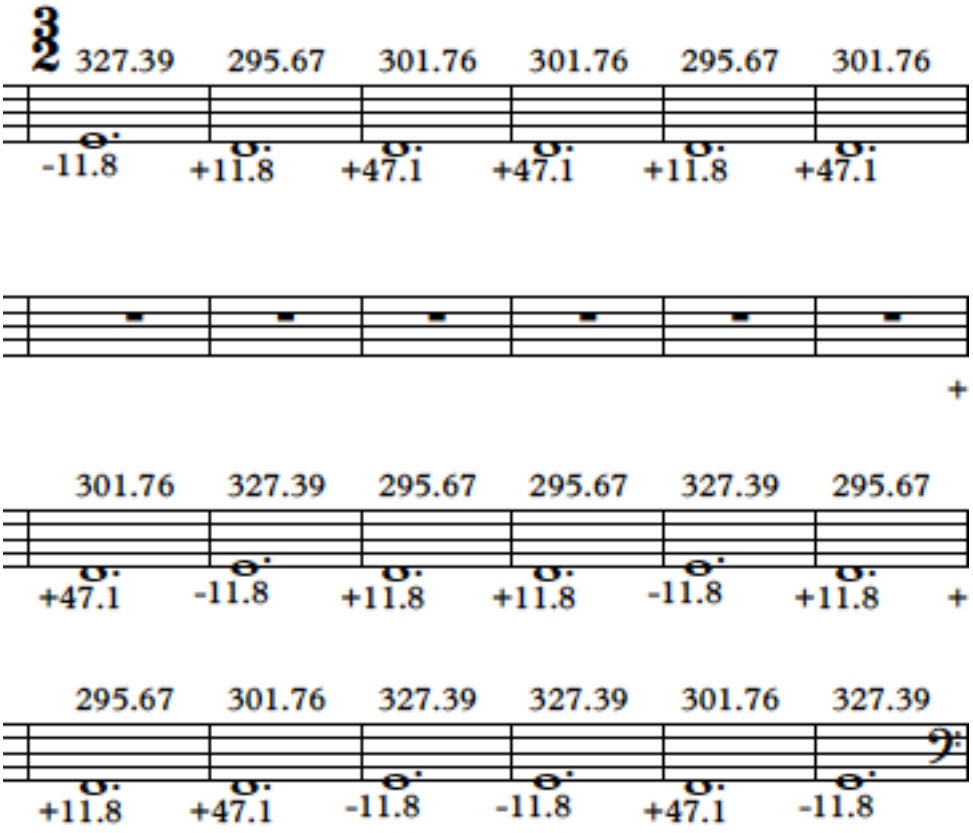

Figure 31: *When all memory is gone* – Timbre shifts. Pitches rotate amongst voices.

Morton Feldman used a similar technique in *Coptic Light* for Orchestra (1986)[151]. Pitches are echoed back and forth within each section of the orchestra, sustaining the harmony for long sections, but have colorful waves of changing timbre over time. This morphing technique functions as a form of sustain pedal for the orchestra.

By using this technique, especially during the long stretches of repetitive 'bell' motives, it is the main element to create the needed dimension of movement. Whilst the microtonal beating patterns inherent to the clusters already have interesting pulsing rhythms going on, adding this extra dimension of movement really brings the material to life. The effect is very beautiful – one recognizes a motive as the same pitch cluster yet the change in sound is dramatic.

5.4. Tuning – 34-Tet

When all memory is gone uses 34 equal temperament tuning with a smaller selection of notes as the scale. Similar as before, the pitches for the scale are selected by listening specifically to beat patterns and playing around until certain motives begin to sound right. It is also a functional consideration: by reducing the staggering amount of pitches, it becomes more practical to perform.

[151] Morton Feldman, *Coptic Light for Orchestra,* compact disc.

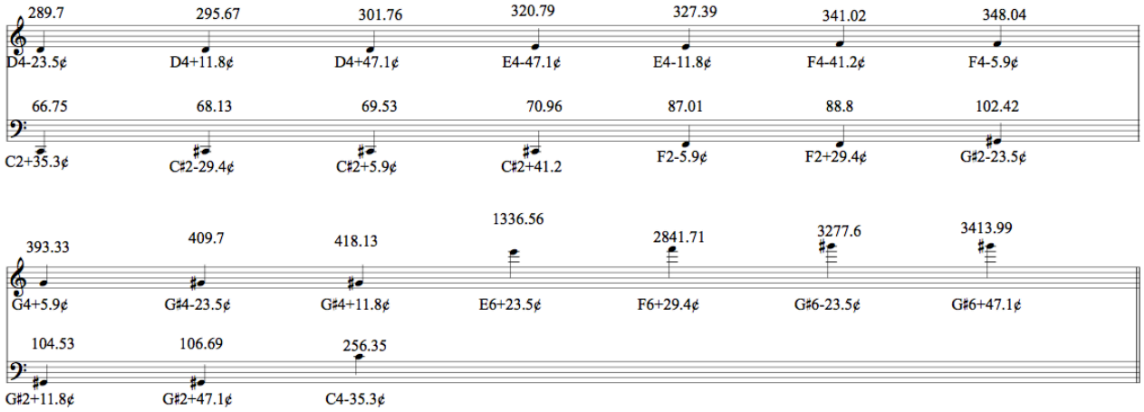

Figure 32: *When all memory is gone* – 34 equal temperament scale.

Giacinto Scelsi's music with its extreme subtlety in terms of pitch fluctuations has already been mentioned as major influence. By dividing an octave into 34 divisions, nearly three intervals per semitone become available. A structure that allows me to stumble on some great sounding beating patterns. At the same time, to my ears it does not sound very dissonant – well perhaps due to the pitches I intuitively used.

5.5. Form

The macro form and development is once again rather simple. The only changes are that of the bell motive expanding in duration and register. There is one section with a 'deconstructed' presentation of the bell motive in which voices are rhythmically staggered instead of playing in unison as before.

Bars	Section	Description	Fig.
1-13	**A**	The music starts with the bell motive in unison rhythm, in the middle register	33
14-33	**B**	Two layers of bell motives. Enlarged bell motive in bottom register.	34
34-36	**C**	Dynamic change and high register bell motive.	
37-85	**B**	All registers play enlarged bell motive with some rhythmic elements.	
86-88	**C**	Back to high register bell motive.	
89-97	**B**		
98-124	**D**	Rhythmical activity: more extreme rhythmic offsets between voices.	35
125-44	**B**		
145-7	**C**	High register bell motive with loud bass and effects.	
148-203	**E**	Similar to B but more enlarged; focus on bass and large spatial effects.	36

Table 1: Overview of form for *When all memory is gone.*

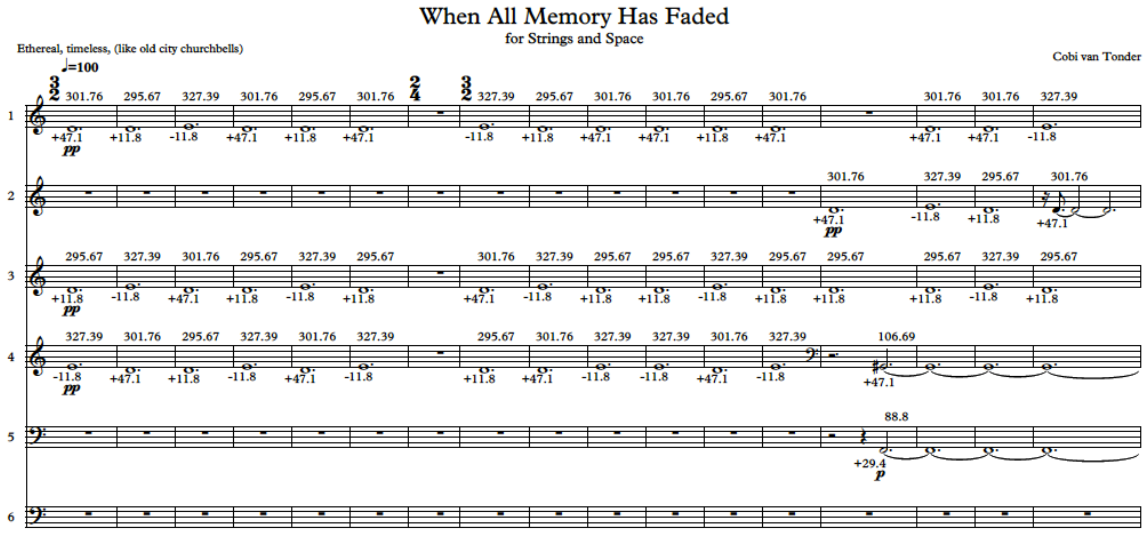

Figure 33: *When all memory is gone,* material in section **A**.

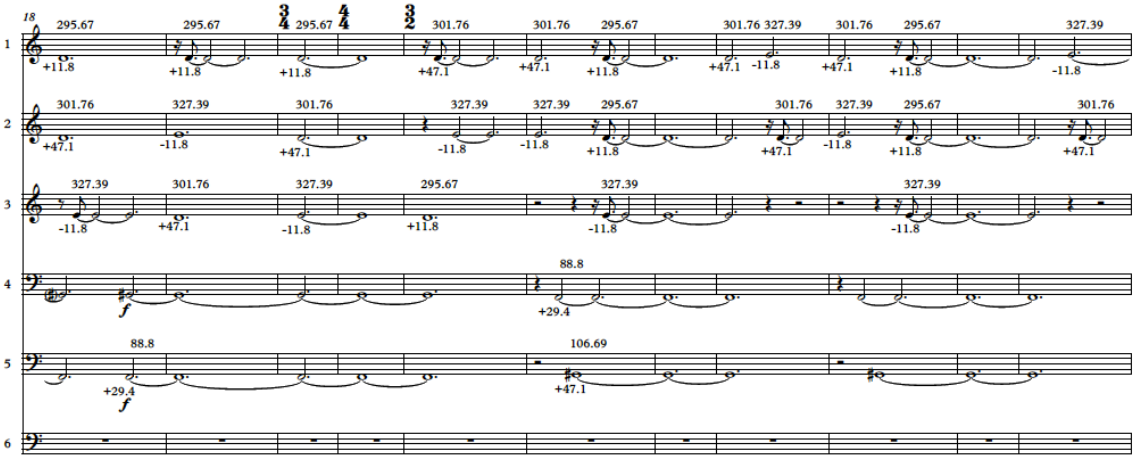

Figure 34: Two layers of bell motives. Enlarged bell motive in bottom register. Material in Section **B.**

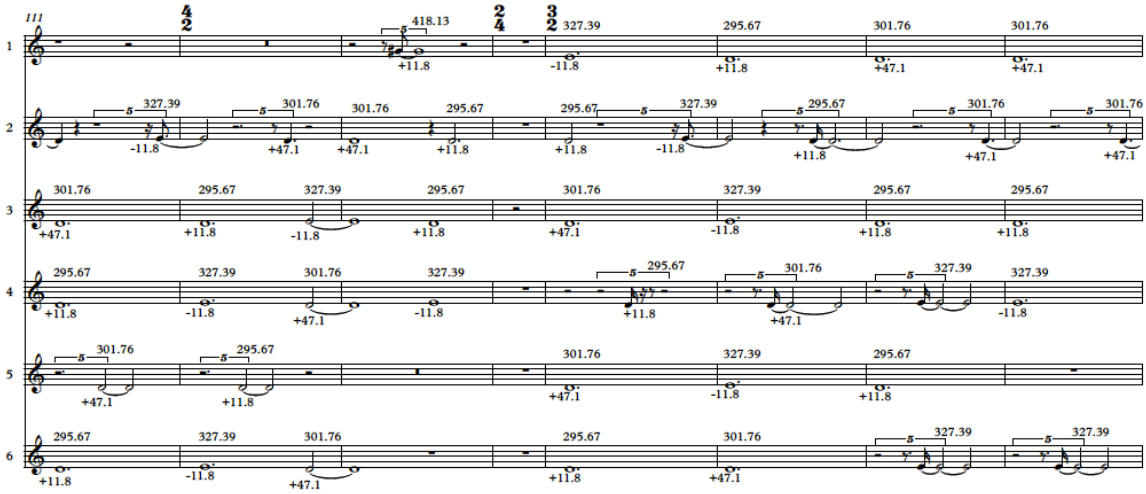

Figure 35: *When all memory is gone* rhythmic deconstruction in section **D**.

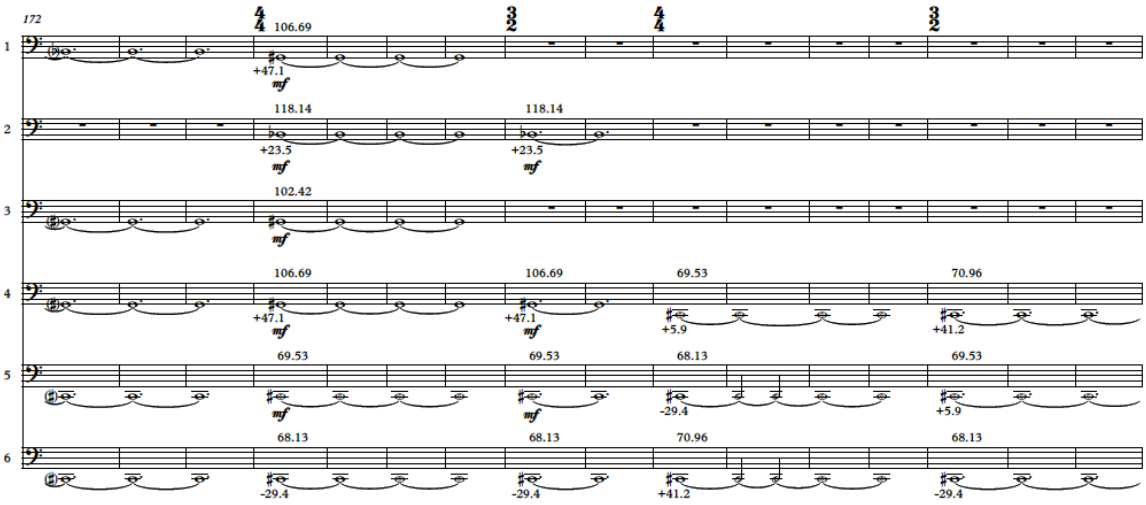

Figure 36: *When all memory is gone,* enlarged end material in section **E**.

Chapter Six: *Drift* and *Gala*

6.1. Introduction

Drift is titled after a Bridget Riley painting *Drift 2* (1966) as a dedication to her. With *Drift 2* the darkness at the edges, the overall ambiguity, off-center symmetry and vibrating ambiguity make for a visual composition of high intrigue.

Figure 37: *Drift 2* (1966) by Bridget Riley.[152]

[152] Bridget Riley, *Drift 2* (WIKIART Visual Art Encyclopedia, 1961).

6.2. Tuning

Drift exists again in a meta tuning system, this time a G harmonic series, 5-tet, 21-tet and 34-tet are all stacked on top of each other. As before I carefully select by ear only a small number of pitches and create a new meta scale from these notes. The result is 34 notes to work with.

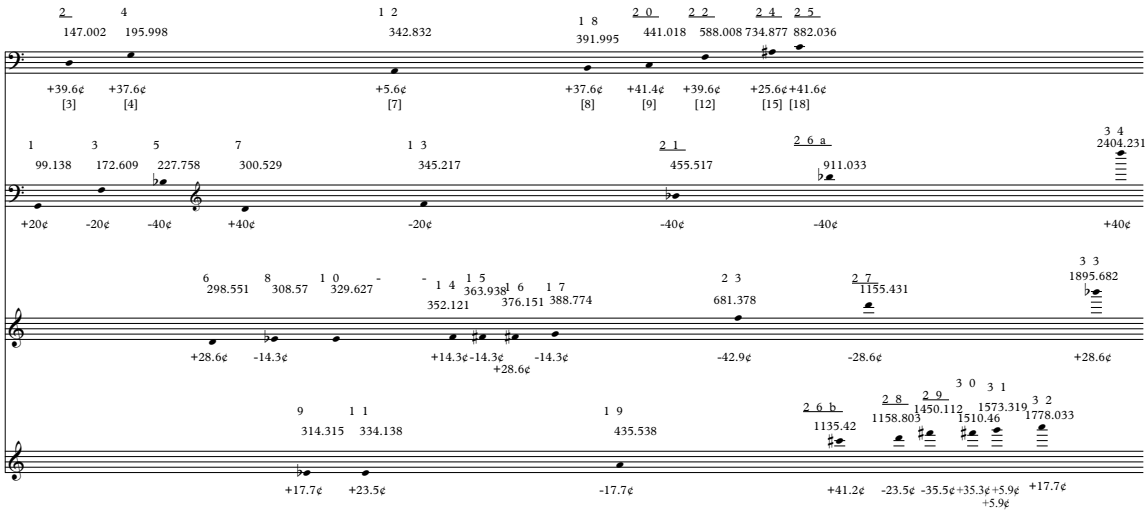

Figure 38: Scales for *Drift* – Top staff contains pitches selected from G-harmonic series with partials in brackets, the second staff contains pitches from 5-tet, third staff, 21-tet and last staff 34-tet.

6.3. Form

Next I attempt to generate chord progressions. They simply do not work – there are interesting elements but the linear progression completely ruins the overall effect.

Tenney's simple yet effective macro forms that can be found for example in pieces like *Saxony* (1978)[153], *Koan* (1971)[154] and *Having Never Written a Note for Percussion* (1971)[155] inspire a different approach. In *Saxony* the material is a single harmonic overtone series of a single note. The notes are presented from low to high in an additive manner over time. Because the vertical direction is so perceptually strong it really feels like one ascends into the heavens or everything becomes lighter and a transformation from gravity to no gravity happens. This motion dominates over the perception of linear time. In *Koan* slow moving string glissandi are set against steady drone pitches with a steady eighth-note rhythm continually crossing two strings. That is the entire macro form: one long gesture. In *Having Never Written a Note for Percussion* (1971), which is a seven and a half-minute long singular gesture, it swells to maximum capacity and fades again in smooth lines.

[153] Tenney, *Saxony,* compact disc.
[154] Tenney, *Koan,* compact disc.
[155] Tenney, *Koan: Having Never Written A Piece For Percussion,* compact disc.

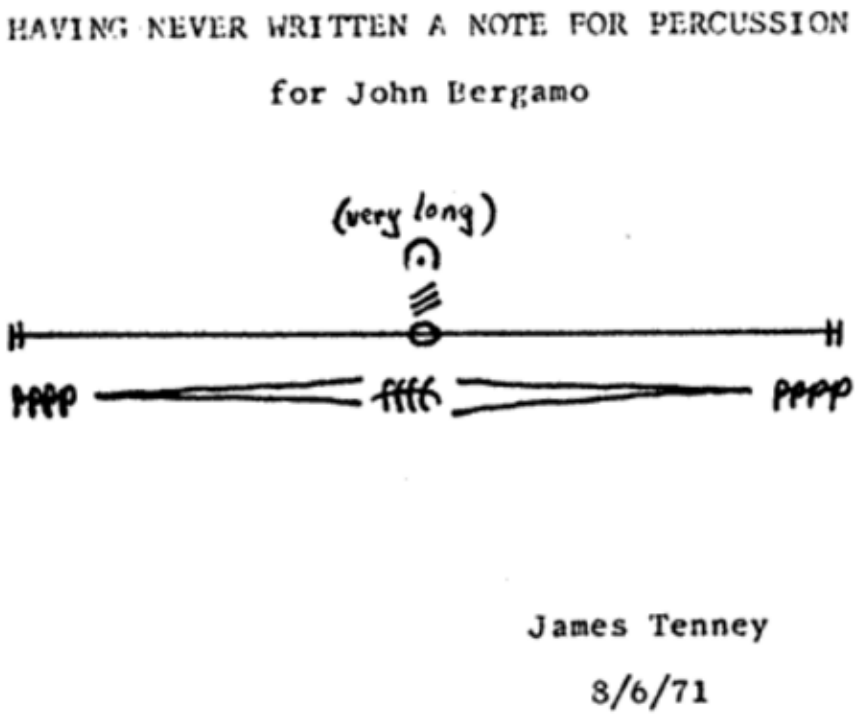

Figure 38: Score for *Having Never Written a Note for Percussion* (1971) by James Tenney.

Inspired by this, I try something really simple: I write down all the notes on one staff and arrange them from low to high (Fig. 39).

Next the form is designed to start from the highest and lowest notes simultaneously and then let them walk in a random crawl kind of way to meet each other somewhere in the middle. This middle turns out to be note number 20 (close to a concert A or 441.018Hz).

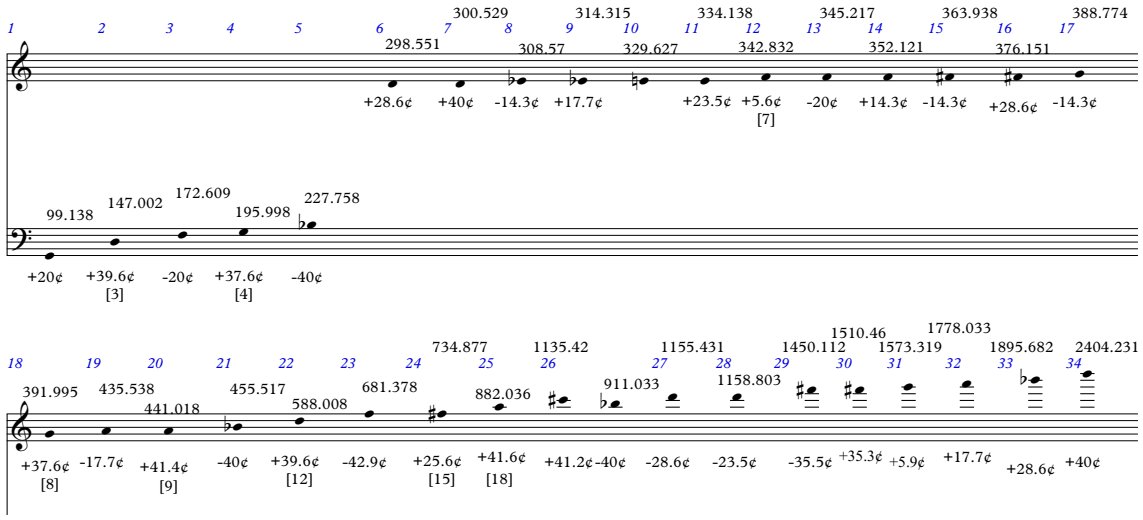

Figure: 39: *Drift,* 34 note meta scale.

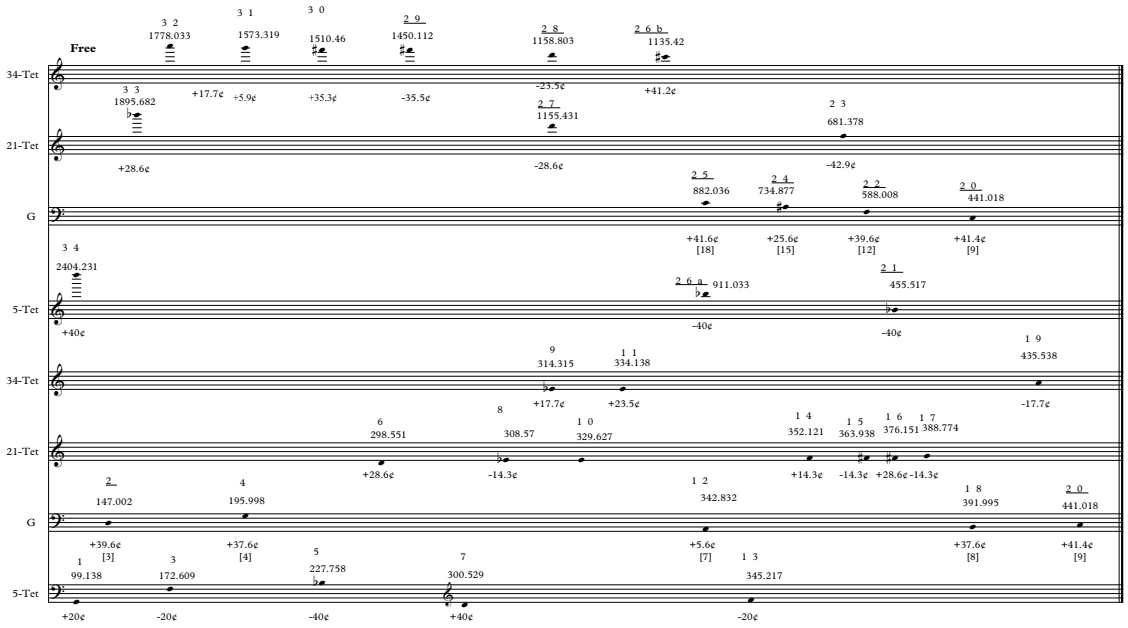

Figure 40: *Drift,* 2 lines: ascending from 1-20 and descending from 34-20.

The only parameter that remains is how to structure this in time. I experiment with space-time notation, but in the end settle with a simple table with indications in 30 sec – 1 min increments. The instructions are that players should intuitively begin the indicated pitch anywhere within a 30-second frame and hold the note to

fade out in time before the next pitch indication. The players should intuitively decide how long they want to hold a note and how slowly or quickly they want to fade out by listening to each other. Dynamics are also free.

Drift Timeline

Use this time-line for approximate durations. Each scale is assigned to three performers numbered 1-12.

Time	G harm			5-Tet		21-Tet		34-Tet				
	1	2	3	4	5	6	7	8	9	10	11	12
0'				34								
					34							
							33			32		
1'								33		31		32
2'				1		1		30				
	2		2						30	29	31	
3'										28		29
											28	
4'					3	3		27				
							27					
										26b		
5'		4			2		33					
											26b	
			25									
6'						26a						
		24			5							
7'						32						
	3			13					6			
8'					7							
		12			13	30	10	8	23	9	29	11
9'	12	4		21			14					
			22		34			15	16			
10'	2											19
			18				17					
					34			31		19		
11'			20									
	20											
12'			20									

Figure 41: *Drift* Timeline.

The total mix is fed into a stereo tape delay that samples and repeats notes back into the mix at two different rates and again functions to elongate pitches and create an overall added textural layer.

6.4. Spectral influences

The 34 note meta scale presents me with somewhat subtle dissonances, which I actually prefer to call vibrations with varying intensities. I have no intention to resolve them into anything but themselves. I really feel like I have hit an important vain with this Tenney-inspired approach to form. Through these simple macro gestures, the microtonal world can open up, breath and reveal itself in vertical directions. When you think of a sunset for example, you think of a very simple and continuous motion: colors shift and change, intensity changes, but everything else is still. The sky doesn't move. This music is similar.

I have also become more aware of the effectiveness in leaving certain parameters open to performers. Again, another Tenney score, *Clang* is a great example. It comes with the following instructions:

> The notation indicates available pitches to be played by sustained-tone instruments (including rolls on the percussion instruments) in the following way: each player chooses, at random, one after another of these available pitches (when within the range of his or her instrument), and plays it beginning very softly (almost inaudibly), gradually increasing the intensity to the dynamic level indicated for that section, then gradually decreasing the intensity again to inaudibility ... After a pause at least as long as the previous tone, each player then repeats this process ... [156]

Wannamaker points out how instructions like these are of major importance to many of Tenney's works and from most European spectral music. '[A] post-Cageian espousal of indeterminacy with regard to certain musical features such as timbre and texture, albeit carefully constrained so as to ensure that the resulting

[156] Wannamaker, *North American Spectralism: The Music of James Tenney*.

variety displays desired aspects of uniformity and evolves in a deliberate fashion.'[157]

6.5. **Variation: *Gala***

Gala is the result of a perceptual experiment. Identical in all ways but one to *Drift,* it is made from the same tunings, the same exact pitches, the same form in terms of two lines starting from highest and lowest pitches and meeting in the middle; the same delay effects, even the same instrumentation. The only thing that is different is the overall duration. Or in other words, the pace at which the performers move through the material. Instead of taking 12-13 minutes to move through the series of notes, it happens at a new pace of 5 minutes. This is an unusually short duration for a drone piece, yet, the result is quite beautiful. Because *Gala* moves at a much faster pace, the colors seem brighter.

157 *Ibid.*

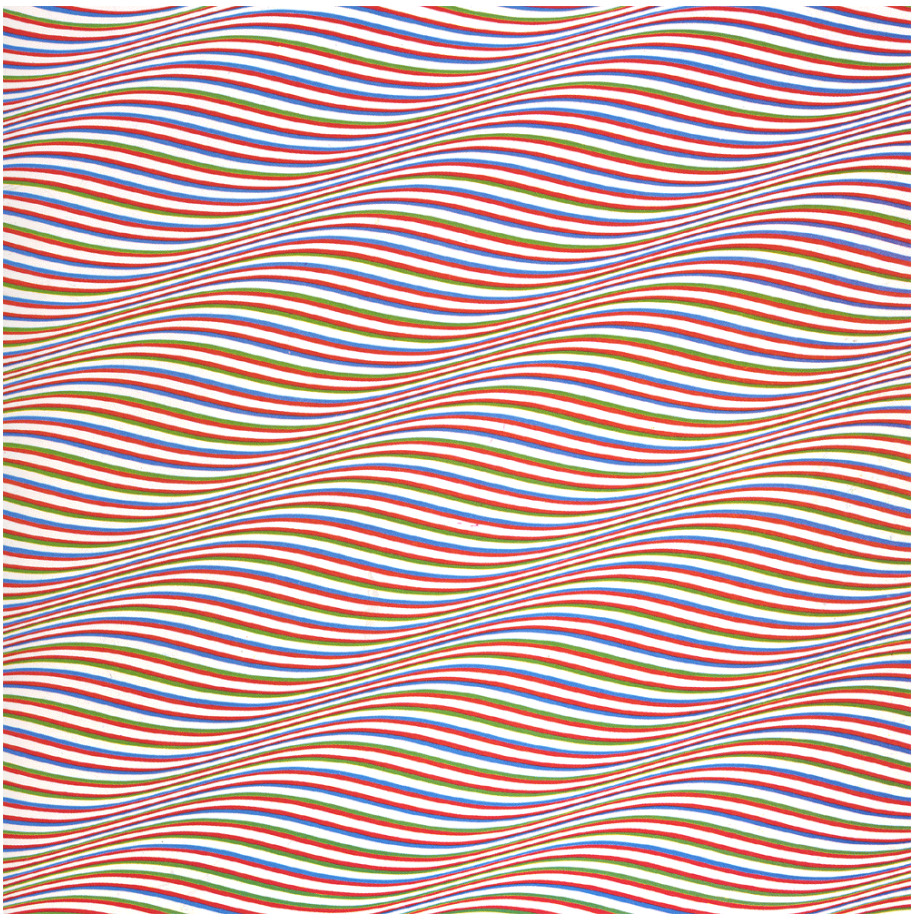

Figure 42: *Gala* (1974) by Bridget Riley.[158]

[158] Bridget Riley, 'Gala' (http://www.karstenschubert.com/artists/31-bridget-riley/works/3688/, 10 April 2016).

Gala Timeline

Time	G harm			5-Tet			21-Tet			34-Tet		
2 -3 performers play each scale, divide notes as necessary.												
0'				34								
10"					34		33					
20"								33		32		
30"				1		1						32
40"										31		
50"	2		2									31
1'								30				
1'10				3	3				30	29		
1'20	4		4							28		29
1'30											28	
1'40		2						27				
1'50			1			5	27					
2'	2			5						26b		
2'10		4			2		33					
2'20						7		6			26b	
2'30	25				1			15	8	9		
2'40												
2'50			25	26b		13	8				9	
3'		24				32			10			
3'10	3			13			14	23				
3'20			12			30						
3'30		2	22					15			29	
3'40	12											
3'50					34	13	17		16			
4'	2	18									11	19
4'10			18									
4'20									23	19		
4'30	20											
4'40			20									
4'50												
5'												

Figure 43: *Gala* Timeline

Chapter Seven: *Mutation 2*

7.1 Introduction

For long I have been wanting to 'visualise' sound waves by devising a method of 3 dimensional steam projection, to visualise in three dimensions the actual sound waves as they interfere and bounce around a room. With *Mutation 2*, I feel that I have found a tactile alternative: one simply needs to move through the room and experience the vibrations of the standing waves and nodes with one's head and body.

They key material in *Mutation 2* is again micro intervals from my own scales, to create beatings. The difference here lies in the execution: it is realised by a Nord Modular 2x synthesizer and therefore the microtonal pitch values have a certain precision that human players cannot achieve. The synthetic sounds are presented at a relatively loud level, so that the glossy sound completely penetrates the space and body.

What I really love about the result is the absolute undeniable physicality of the sounds. They contain so much energy and the listener can move through the room and literally explore the waves. From turning the head to the sides, left right the sound changes dramatically. Moving slightly forward or backwards, one can step into a 'hotspot' of pulsing beats. One more step and the effect is completely gone, one only hears the two tones.

At some points during the progression of the piece, I literally feel my inner ear react to the sound. I feel a vibration in the eardrum area, a kind of sympathic

resonance. Something prior to otoacoustic emissions. At a louder volume full otoacoustic emission happens on some of the microtonal clusters.

The oscillating pulsing sounds can be compared to visual flickering or strobe lights at different tempos. It has a disorienting, hallucinatory effect (when played at loud enough level), at once putting the listeners in a kind of isolation that may feel subliminal. This also has a powerful effect of being in the absolute 'now' or present – there is no tempo insinuated, only the constant bombardment of flickering rhythms. When played at softer levels, it still has some of the effect and an austere presence that I would compare to a David Lynch slow camera movement through a dark corridor with red curtains at the end. I say this because it feels to me as if the music completely lacks emotional content and it makes it slightly eerie. The response I feel is as if I experience my body without the soul in it, as if in a dream.

7.2 **Form**

For *Mutation 2,* I have approached the structure as modules strung together linearly as if beads on a string: each module is a little microtonal cluster ranging from 2 – 4 pitches. Thus the macro form is extremely simplistic. Instructions on the score indicate that these clusters must fade in at the beginning and fade out at the ends in order to accommodate crossfades and smooth morphs between events. This allows the texture to remain smooth, glossy and like a glow that pulses and changes colour from bead to bead. At the start, the changes seam weak. It would be more typical to use much slower drone like morphs. I deliberately decided to stick to 30-second modules. After a while it becomes like a slow ticking clock, the monotonous changes fall back to make space for the flickering sensations to dominate the focus and I think it does work after all.

There is no build up, no climax, and no change in form, just an alien kind of landscape.

7.3 **Texture: order and chaos**

The overall texture has two added sound layers: one extreme foreground and one sounding far away. Whilst the main pulsing patterns are smooth, glossy and have a definite periodicity, the foreground and background textures are dry, airy, scratchy, grainy and more chaotic.

The foreground material is that of a guitarist improvising to create minute surface sounds – short rhythmic pianissimo patterns and soft scratchy/airy sounds. The guitar sounds aim to sound chaotic, but comes across as predictable. Still there is a large distance in order between the periodicity of the difference tones and the foreground patterns. These sounds are used in extremely sparse fashion. It is intended to be the absolute surface detail, used just enough to create contrast and accentuate overall depth. In the background a grainy cloud like texture fades in and is an important textural element of contrast both spatially and texturally to the rest.

This cloud is made up from running Markov chains (transition probabilities) in a Max patch made by Karlheinz Essl[159] to control the attack, sustain, decay and release parameters of two noise oscillators on a Nord Rack Virtual Analogue synthesizer; the attack, sustain, decay and release parameters of a filter and also the resonance and cut-off frequencies. A 'metro' timing object running at varying superfast speeds, in turn controlled by other random objects, controls the patch

[159] Karlheinz Essl, 'The Real Time Composition Library (Rtc-Lib)' (http://www.essl.at/works/rtc.html, 10 February 2014).

and Markov chains, to produce extremely fast yet temporally varying, noise patterns. Long stretches of sound were recorded and went through a second editing process of being pitch shifted and manipulated in terms of a modulating playback speed to reach a final effect and texture of a cloud like windy drone – something that doesn't sound synthesized at all but rather natural. The effect is that the foreground beating against the noisy texture creates a kind of gapper effect. It accentuates the beating rhythms in a very subtle textural way.

The guitar foreground sounds are in comparison much rougher and therefore re-emphasize the spatial perspective or distance between foreground, middle- and background.

7.4 **Tuning system**

The scales consist of pitches carefully chosen from 21-tet and 34-tet tunings:

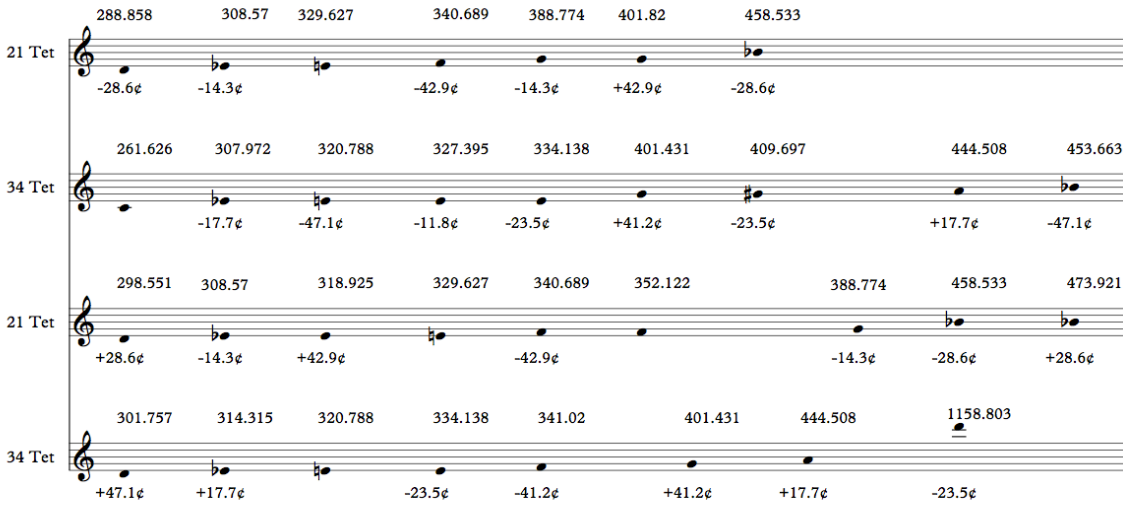

Figure 44: *Mutation 2* scales selected from 21-tet and 34-tet tunings.

Here are the frequencies again as text form as they appear in order in the score:

Bar nr:	21	34	21	34
1	-	-	308.57	314.314789
2	340.688965	329.627	-	-
3	-	-	340.689	334.138336
4	308.57	320.788391	-	-
5	-	-	329.627411	334.138336
6	308.57	320.788391	329.627411	334.138336
7	318.924988	320.788391	-	-
8	-		308.57	314.314789
9	340.688965	320.788391	-	-
10	-	307.971832	352.121735	341.020233
11	388.773926	-	308.57	314.314789
12	401.820312	409.698608	388.773926	401.430786
13	388.773926	401.430786	-	-
14	458.533356	453.663269	473.920715	444.508209
15	388.773926	401.430786	340.689	320.788
16	458.533356	453.663269	308.57	444.508209
17	340.688965	261.625671	329.627411	334.138336
18	458.533356	453.663269	473.920715	444.508209
19	340.688965	261.625671	329.627411	1158.802856
20	329.627411	261.625671	329.627411	334.138336
21	–	-	298.551361	301.756866
22	288.857941	-	329.627411	-

Table 2: Overview of frequencies used in *Mutation 2.*

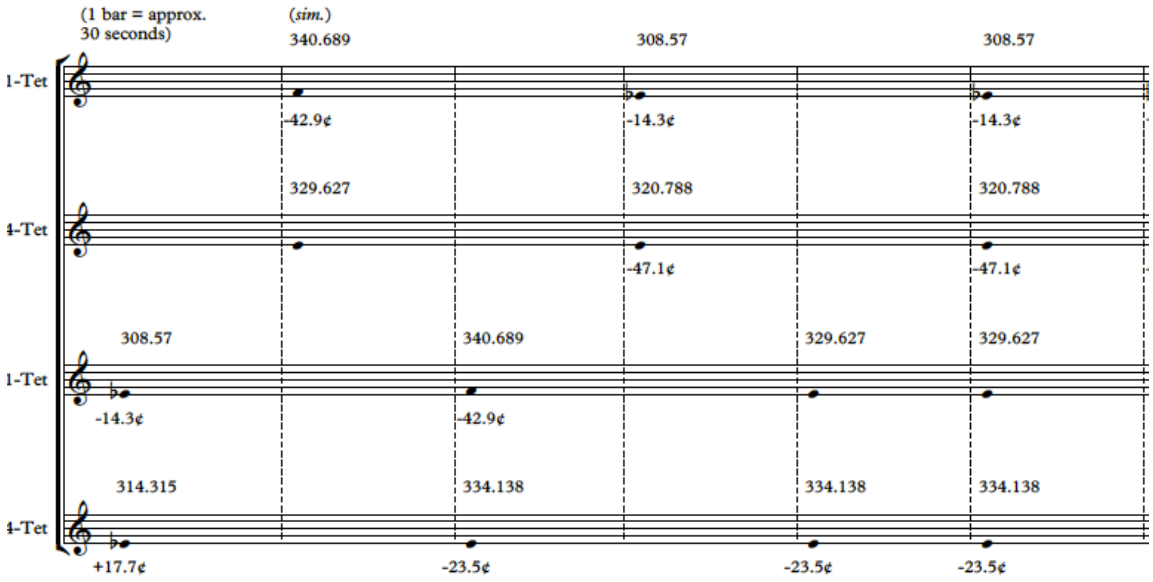

Figure 45: *Mutation 2,* bars 1-6.

With the following table, I aim to demonstrate the beating frequencies that arise during the first 10 bars. Because of instrumentation, voices 1 & 2 and voices 3 & 4 perceptually group together. As the piece progresses this distinction get more vague and I am not at all sure what exactly happens. It could be that when all four pitches sound simultaneously, there are acoustic by products for each possible combination. Also consider that there may be beat frequencies of two simultaneous beat frequencies such as in bar 6.

Bar nr:	21	34	Beating Frequencies	21	34	Beating	Meta Beating
1	-	-		308.57	314.314789	5.745	
2	340.688965	329.627	11.06	-	-		
3	-	-		340.689	334.138336	6.551	
4	308.57	320.788391	12.218	-	-		
5	-	-		329.627411	334.138336	4.511	
6	308.57	320.788391	12.218	329.627411	334.138336	4.511	7.707
7	318.924988	320.788391	1.864	-	-	-	
8	-			308.57	314.314789	5.745	
9	340.688965	320.788391	19.9	-	-	-	
10		307.971832		352.121735	341.020233	11.1	

Table 3: Frequencies, difference tones (indicated as beating frequencies) in *Mutation 2.*

When all four voices are present the preceding material also affects what is heard. It is as if the ear remembers the previous relationships and they prevail to some extent to manipulate how the next sound is perceived. Kendall, Haworth and Cadiz point out that: 'For two sinusoidal signals with frequencies f1 and f2 such that f2 > f1, the sum and difference tones have the frequencies f1 + f2 and f2 – f1 respectively. […] [There are] additional combination tones with the frequencies f1 + N(f2 - f1)'.[160]

To create and work musically with distortion-product otoacoustic emissions (DPOAE) they point out the following:

[160] Kendall, Haworth and Cádiz, 'Sound Synthesis with Auditory Distortion Products.'

> Of the many distortion products, two types are potentially the most useful to music and sound synthesis because of the ease with which listeners can recognize them: the quadratic difference tone (f2 – f1), QDT, which obeys a square-law distortion and the cubic difference tone (2f1 – f2), CDT, which obeys cubic-law distortion. […] The cubic difference tone is the most intense distortion product and is directly observable to the listener even when acoustic stimuli are at relatively low-intensity levels. Because the tone's frequency (2f1 – f2) generally lies relative close to f1 […] The quadratic difference tone (f1 – f2) requires a higher stimulus intensity to be audible, but because the resultant tone's frequency generally lies far below the stimulus frequencies and thus be more easily recognized, it has been a topic of musical discourse since its discovery by Tartini in 1754. [161]

It feels like there is a lot of potential in this material. It is very likely to become a potential future research project for me. In *Mutation 2*, I started off with the assumption that I understand the physics of interference patterns, third tones, beating patterns, but upon real experimentation and listening, I have come to realize that there are a lot of ephemeral aspects about this work. Different performance spaces bring their inherent acoustic qualities and obstacles. There are many factors that influence the end perception of this type of material. I have clearly just touched the surface and would like to learn how to run accurate analysis and visualizations on this material, in order to have a more exact understanding of the perceptual and physical properties of these sounds. Working site-specifically on pieces, in the same fashion as Amacher did, has obvious practical advantages that I would like to exploit. As already mentioned in the introduction, this material is 'surface' taken to one of its audio-physical/acoustic-architectural extremes and that is very exciting.

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[161] Kendall, Haworth and Cádiz, 'Sound Synthesis with Auditory Distortion Products.'

Chapter Eight: Conclusion

The portfolio has been contextualised and described in detail according to the most prominent compositional concerns: movement as determined by colour, form, texture and space. It has been framed within a contemporary context, including influences from composers influenced by Abstract Expressionism such as Volans and Feldman, Spectral music, minimalist electronic music, drone music and sound art influences.

Through the contextualization process, I have discovered many similarities between my work and mentioned composers, often in retrospect, after these pieces were already finished. It serves as a confirmation to the strength of these compositional ideas as worthy of further pursuit. Each piece has presented its own unique challenges and lessons, as well as new territory that need to be further explored.

String Quartet No 1 started with a simple idea to use 4 lines of glissade to expose microtonal qualities between shrinking and expanding intervals. Until working on this piece I had no particular interest in microtonal music. It opened up a whole new way of listening to sound and lead me to explore the Spectral composers, John Chowning's *Stria,* alternative tunings, Éliane Radigue's instrumental music and to discover Scelsi's music.

With *Fata Morgana* the textural result surprised me. The potential of glissade used in pitch field masses, and of dovetailed Shepard's tone motives, leaves room for further explorations. The adding of really simple effects to an acoustic setting to expand performers' natural abilities and with it the overall texture and space are powerful techniques to be exploited further in future works. Knowing that this

material works, I am very curious to translate it into pieces for large ensemble or orchestra in order to expand the overall timbre.
It was an important process for me to go through the actions of creating my own unique tuning systems or scales, to try out combinations and ring them out as I did with *Haute Rorschach, When all memory is gone, Drift, Gala and Mutation 2.*

The motivation for this comes from a deeply personal and political point: due to the complex political history of South Africa, I have come to question a lot of things surrounding identity and ownership. Whilst I admire someone who can say: I am Irish, this is my history, this is the place where all my family stories lie; or I am Japanese, or American, I really feel that I cannot say the same thing. My family history and stories are intermingled with the gruesome political history of South Africa of the past 400 years and I can not find my own identity in there. I also cannot pretend that I fit into another place because some ancestors over 19 generations back, lived there. This has made me question any notions of ownership: trace it back in time, and every powerful country has colonized, stolen and built their wealth and culture at the loss of others.

At least in my music, I can create and build systems and structures that support and allow musical life forms that are original and 'not stolen' from anywhere. By creating my own tuning systems, I can find colours that nobody else is using. If by serendipity or chance these scales sound similar to an ancient Greek scale, or African tunings or another composers' music, it is great, but important for me is that I have arrived at the material by an authentic method. Perhaps within this notion, I come closest to being African: by creating my own unique tunings. Perhaps also telling is that I do not settle to one tuning, but instead look forward to probably a lifelong shape shifting of tunings as well as musical techniques that allow for shifting hues, tints, shades and tinges.

With colour comes movement and vibration. With movement and vibration comes space. *When all memory is gone, Haute Rorschach, Mutations 2, Drift, Gala* and *Fata Morgana* all make use of virtual acoustics as an active ingredient to emphasize and enhance acoustic space and the listening experience.
In one strand of future work, I would like to combine my previous experience in sound art with my newly expanded compositional techniques, and apply this to virtual reality technology spaces, first starting with a collaboration to create the sound for an Oculus Rift (a new virtual reality technology) project. It comes with a vibration body pack, and similar to my *Infrasound Bed*, I would like work in counterpart with what is physically felt and what is heard via headphones.

Drift and *Gala,* made me aware of the sensational life that certain instruments can add to a piece. Whilst working I used synthesis to listen to my ideas, but upon hearing the hardingfeles, violins and shakuhachi perform the same material it became thrilling. With future works, I want to expand the microtonal ideas for unique instrumental combinations and full orchestra to expand the overall texture and impact. At the same time, with *Mutation 2* the synthesized sounds also hold promise; and being based in Berlin, synthesizer city, I hope to collaborate with various electronic musicians who build their own synthesizers and this way expand the machine versions of pieces as well.

I am grateful for having had the opportunity during the past four years to explore many new ideas in my compositional practice. It has also been wonderful to research the music of a vast amount of highly inspirational composers. Through this process I have gained a clearer view of which aesthetical elements matter the most to me and look forward to continue my work with this added experience and maturity. I hope the music can speak for itself.

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Appendix A

Microtonal Scales used in Haute Rorschach

For a twelve tone equal interval (equal temperament) system, the difference in frequency from one note to the next is 2^(1/12) (two to the power of one twelfth). Start for example on 100Hz and multiply 100*2^(1/12) = 105.9, then 105.9*2^(1/12) = 112.2; continue until you have done this twelve times and reach the octave above at 200Hz.

For thirteen-tone equal temperament, just replace the 12s in the equation above with 13s (and carry out the calculation 13 times).[162]

Based on this math, the following temperaments were calculated starting on C (65.406395Hz) going up to the edge of perception at +-20KHz each time.

Octave divided into 3 equal intervals:

65.406395 82.406891 103.82618 130.81279 164.813782 207.652359 261.62558 329.627563 415.304718 523.25116 659.255127 830.609436 1046.502319 1318.510254 1661.218872 2093.004639 2637.020508 3322.437744 4186.009277 5274.041016 6644.875488 8372.018555 10548.082031 13289.750977 16744.037109 21096.164062

Octave divided into 5 equal intervals:

65.406395 75.132217 86.304253 99.13755 113.879143 130.81279 150.264435 172.608505 198.275101 227.758286 261.62558 300.52887 345.21701 396.550201 455.516571 523.25116 601.057739 690.434021 793.1 911.033142 1046.502319 1202.115479 1380.868042 1586.2 1822.066284 2093.004639 2404.230957 2761.736084 3172.401611 3644.132568 4186.009277 4808.461914 5523.472168 6344.803223 7288.265137 8372.018555 9616.923828 11046.944336 12689.606445 14576.530273 16744.037109 19233.847656 22093.888672

[162] Thanks to Michael Gendreau who explained this math to me.

Octave divided into 8 equal intervals:

65.406395 71.32618 77.781754 84.821602 92.498611 100.870453 110. 119.955856
130.81279 142.652359 155.563507 169.643204 184.997223 201.740906 220. 239.911713
261.62558 285.304718 311.127014 339.286407 369.994446 403.481812 440. 479.823425
523.25116 570.609436 622.254028 678.572815 739.988892 806.963623 880. 959.646851
1046.502319 1141.218872 1244.508057 1357.14563 1479.977783 1613.927246 1760.
1919.293701 2093.004639 2282.437744 2489.016113 2714.29126 2959.955566
3227.854492 3520. 3838.587402 4186.009277 4564.875488 4978.032227 5428.58252
5919.911133 6455.708984 7040. 7677.174805 8372.018555 9129.750977 9956.064453
10857.165039 11839.822266 12911.417969 14080. 15354.349609 16744.037109
18259.501953 19912.128906

Octave divided into 13 equal intervals:

65.406395 68.988449 72.766678 76.751823 80.955223 85.388824 90.065239 94.997757
100.2 105.687996 111.476112 117.581223 124.020683 130.812805 137.976913
145.533371 153.503662 161.910461 170.777664 180.130493 189.995529 200.4
211.376007 222.95224 235.16246 248.041382 261.625641 275.953857 291.066772
307.007355 323.820953 341.555359 360.261017 379.991089 400.801697 422.752045
445.90451 470.324951 496.082794 523.251282 551.907715 582.133545 614.014709
647.641907 683.110718 720.522034 759.982178 801.603394 845.504089 891.809021
940.65 992.165588 1046.502563 1103.81543 1164.26709 1228.029419 1295.283813
1366.221436 1441.044067 1519.964355 1603.206787 1691.008179 1783.618042 1881.3
1984.331177 2093.005127 2207.630859 2328.53418 2456.058838 2590.567627
2732.442871 2882.088135 3039.928711 3206.413574 3382.016357 3567.236084 3762.6
3968.662354 4186.010254 4415.261719 4657.068359 4912.117676 5181.135254
5464.885742 5764.17627 6079.857422 6412.827148 6764.032715 7134.472168 7525.2
7937.324707 8372.020508 8830.523438 9314.136719 9824.235352 10362.270508
10929.771484 11528.352539 12159.714844 12825.654297 13528.06543 14268.944336
15050.398438 15874.649414 16744.041016 17661.046875 18628.273438 19648.470703
20724.541016

Octave divided into 21 equal intervals:

65.406395 67.601288 69.87 72.214508 74.637863 77.142548 79.731277 82.406883
85.172279 88.030472 90.984581 94.037819 97.19352 100.455116 103.826164
107.310341 110.911438 114.633377 118.480217 122.456154 126.565514 130.812775
135.20256 139.739655 144.429001 149.275711 154.28508 159.46254 164.813751
170.344528 176.060913 181.969131 188.075607 194.387009 200.910202 207.652298
214.620651 221.822845 229.266724 236.960403 244.912262 253.130981

261.625488 270.40506 279.479248 288.857941 298.551361 308.57 318.924988
329.627411 340.688965 352.121735 363.938171 376.151123 388.773926 401.820312
415.304504 429.241211 443.645599 458.533356 473.920715 489.824432 506.261841
523.250854 540.81 558.958374 577.715759 597.1026 617.14 637.85 659.2547 681.377808
704.243347 727.876221 752.302124 777.547729 803.640503 830.608887 858.4823
887.291077 917.066589 947.841309 979.648743 1012.52356 1046.501587 1081.62
1117.916626 1155.431396 1194.205078 1234.28 1275.7 1318.509277 1362.755493
1408.486572 1455.752319 1504.604126 1555.095337 1607.280884 1661.217651

1716.964478 1774.582031 1834.133057 1895.682495 1959.297363 2025.046997
2093.003174 2163.239746 2235.833252 2310.862793 2388.410156 2468.56 2551.4
2637.018555 2725.510986 2816.973145 2911.504639 3009.208252 3110.190674
3214.561768 3322.435303 3433.928955 3549.164062 3668.266113 3791.36499
3918.594727 4050.093994 4186.006348 4326.479492 4471.666504 4621.725586
4776.820312 4937.119629 5102.79834 5274.037109 5451.021973 5633.946289
5823.009277 6018.416504 6220.381348 6429.123535 6644.870605 6867.85791
7098.328125 7336.532227 7582.73 7837.189453 8100.187988 8372.012695 8652.958984
8943.333008 9243.451172 9553.640625 9874.239258 10205.59668 10548.074219
10902.043945 11267.892578 11646.018555 12036.833008 12440.762695 12858.24707
13289.741211 13735.71582 14196.65625 14673.064453 15165.46 15674.378906
16200.375977 16744.025391 17305.917969 17886.666016 18486.902344 19107.28125
19748.478516 20411.193359

Octave divided into 34 equal intervals:

65.406395 66.753502 68.128349 69.531517 70.963585 72.425148 73.916809 75.439194
76.992935 78.578674 80.197075 81.848808 83.53456185.255028 87.010933 88.803001
90.631981 92.498627 94.403717 96.348045 98.33242 100.357666 102.424622
104.534149 106.687126 108.884445 111.127022 113.415787 115.751686 118.135696
120.56881 123.052032 125.586403 128.172974 130.812805 133.507019 136.256714
139.063049 141.927185 144.850311 147.833633 150.878403 153.985886 157.157364
160.394165 163.697632 167.069138 170.51 174.021896 177.606033 181.263992
184.997284 188.807465 192.696121 196.664871 200.715363 204.849274 209.068329
213.374283 217.768921 222.254074 226.831604 231.503403 236.271423 241.13765
246.104095 251.172836 256.345978

261.625671 267.014099 272.513489 278.12616 283.854431 289.7 295.667328
301.756866 307.971832 314.314789 320.788391 327.395325 334.138336 341.020233
348.043854 355.212128 362.528046 369.994629 377.61499 385.392303 393.33
401.430786 409.698608 418.136719 426.748627 435.537903 444.508209 453.663269
463.006866 472.542908 482.27536 492.208252 502.345734 512.692017 523.251404
534.028259 545.027039 556.25238 567.708923 579.401428 591.334717 603.513794
615.943726 628.629639 641.576843 654.79071 668.276733 682.040527 696.087769
710.424316 725.056152 739.989319 755.23 770.784668 786.659668 802.861633
819.397278 836.273499 853.497314 871.075867 889.016479 907.326599 926.013794
945.085876 964.550781 984.416565 1004.691528 1025.384033 1046.502808
1068.056519 1090.054077 1112.504761 1135.417847 1158.802856 1182.669434
1207.027588 1231.887451 1257.259277 1283.153687 1309.581421 1336.553467
1364.081055 1392.175537 1420.848633 1450.112305 1479.978638 1510.46 1541.569336
1573.319336 1605.723267 1638.794556 1672.546997 1706.994629 1742.151733
1778.032959 1814.653198 1852.027588 1890.171753 1929.101562 1968.83313
2009.383057

2050.768066 2093.005615 2136.113037 2180.108154 2225.009521 2270.835693
2317.605713 2365.338867 2414.055176 2463.774902 2514.518555 2566.307373
2619.162842 2673.106934 2728.162109 2784.351074 2841.697266 2900.224609
2959.957275 3020.920166 3083.138672 3146.638672 3211.446533 3277.589111
3345.093994 3413.989258 3484.303467 3556.065918 3629.306396 3704.055176
3780.343506 3858.203125 3937.66626 4018.766113 4101.536133 4186.01123
4272.226074 4360.216309 4450.019043 4541.671387 4635.211426 4730.677734
4828.110352 4927.55 5029.037109 5132.614746 5238.325684 5346.213867 5456.324219

5568.702148 5683.394531 5800.449219 5919.914551 6041.840332 6166.277344
6293.277344 6422.893066 6555.178223 6690.187988 6827.978516 6968.606934
7112.131836 7258.612793 7408.110352 7560.687012 7716.40625 7875.33252
8037.532227 8203.072266 8372.022461 8544.452148 8720.432617 8900.038086
9083.342773 9270.422852 9461.355469 9656.220703 9855.1 10058.074219
10265.229492 10476.651367 10692.427734 10912.648438 11137.404297 11366.789062
11600.898438 11839.829102 12083.680664 12332.554688 12586.554688 12845.786133
13110.356445 13380.375977 13655.957031 13937.213867 14224.263672 14517.225586
14816.220703 15121.374023 15432.8125 15750.665039 16075.064453 16406.144531
16744.044922 17088.904297 17440.865234 17800.076172 18166.685547 18540.845703
18922.710938 19312.441406 19710.2 20116.148438 20530.458984

Appendix B

Max/MSP Tuning Patch

The purpose of this patch is to be able to send live MIDI values from a sequencer such as Sibelius (or Ableton) and transform these notes (in real-time) into any chosen frequency value sets (from here on referred to as *scales*). These values can next be sent to synthesizers or devices responsive to midi. The program is specifically designed with microtonal scales in mind, but is also capable of transforming incoming notes into any possible set of pitches. It is a very simple yet practical way to quickly listen to various tunings and store them for future use. I ended up using it for a major part of the pieces in the portfolio.

The desired *scales* are stored in lists called 'zl lookup' tables. A frequency-to-midi converter is used to translate these pitches back into midi-note values plus matching pitch-bend values in order to get the closest microtonal representation possible. In turn the software instruments or synthesizer that are capable of responding to midi-pitch-bend values of 0-127, where the pitch-bend-range is set to 1 semitone, can then play these notes.

In this context, the midi sequencer sends midi-notes that are merely placeholders. In Fig. B1 is an example of a chromatic line from middle C in the bottom staff. The top staff is an example of the tuner output.

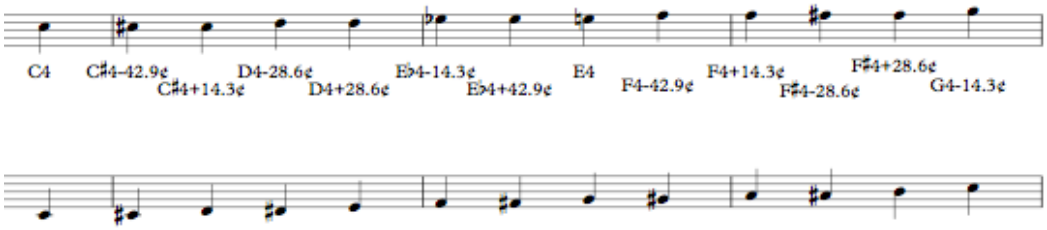

Figure B1: Example of pitch conversion.

The tuner patch is currently designed for routing to 6 individual *scales.* These scales are preloaded into the system. It also accommodates 6 independent midi-channels or independent voices.

The environment is divided into 4 panels that are color-coded for ease of use (Fig. B2).

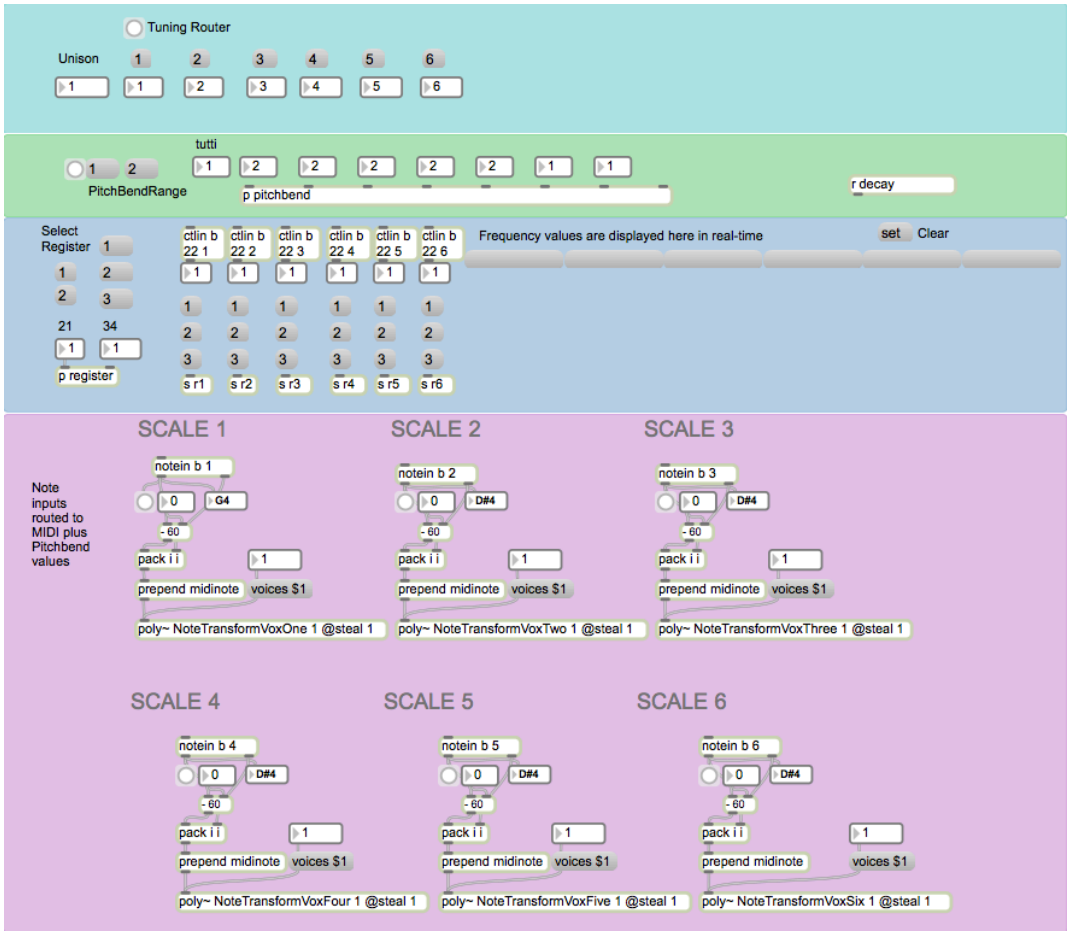

Figure B2: Overview of Tuner Patch.

Panel 1:
The *Tuning Router* points to which frequency set must be used for a channel. There exists a lot of flexibility: incoming voices can easily be switched to any of the 6 different frequency sets. Each number represents a scale. They can also all be routed to the same scale when the 'Unison' button is used.

Panel 2:
Hand-in-hand with a selected scale goes selecting the *Pitch-bend-range*. For any scales that have only equal temperament values the pitch-bend-range must be set to 2 semitones. For all microtonal incremented scales it must be set to 1 semitone (to allow the pitch-bend message to have a range of 128 small increments per semitone).

Panel 3:
Select Register: when a *scale* has more than 128 pitches in total, it gets divided into different ranges. This is because of the built-in midi limitation of 0-127 values per scale. Especially when working with 21-Tet, 34-Tet or any other scale that has many values in it, it is useful to be able to switch register either for all scales collectively or per channel via an independent controller message.

To the right-hand side of panel three is also a real-time frequency display for each channel. This is handy to see what is going on (Fig. B3).

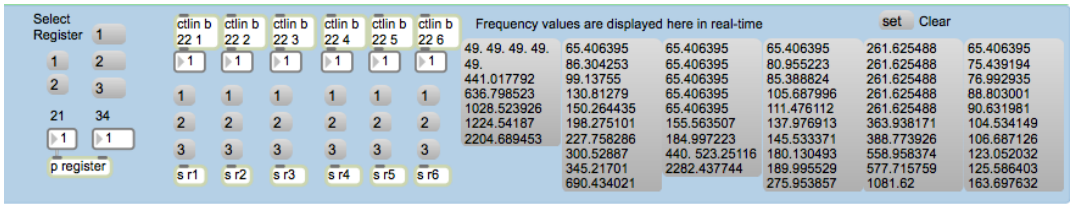

Figure B3: Close-up of Panel 3 with live frequency values.

Panel 4:
The *Midi-Routing* panel allows for setting up routing, such as incoming midi-channels and ports as well as outgoing midi channels and ports. It also contains the *poly~ NoteTransformVox* object that contains the transformation functionality. As you can see there is one for each of the 6 channels.

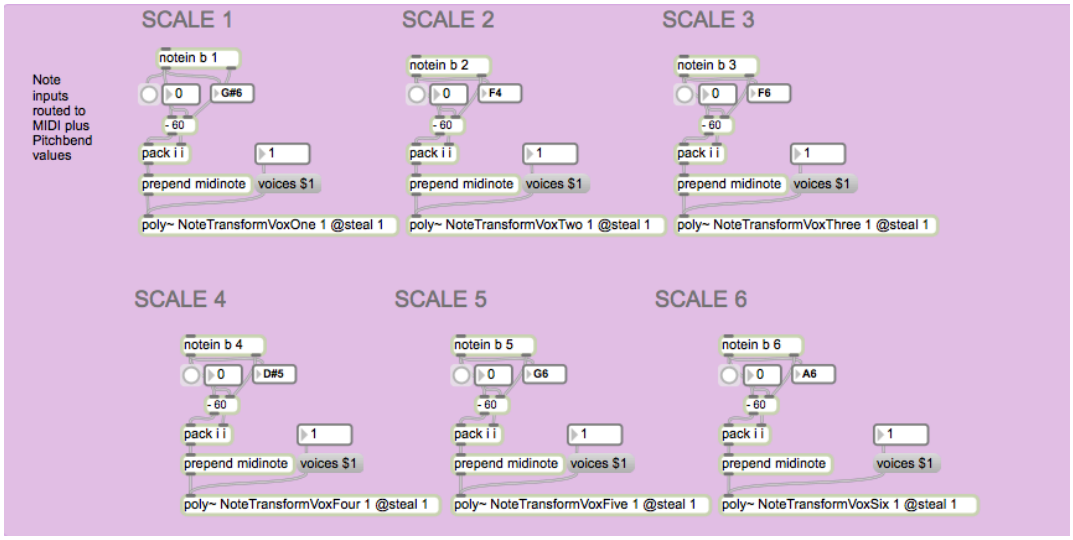

Figure B4: Close-up of Panel 4.

Inside the *poly~ NoteTransformVox* object is two important sub-patchers, *p repitch* and *p pitch-bend-midi.*

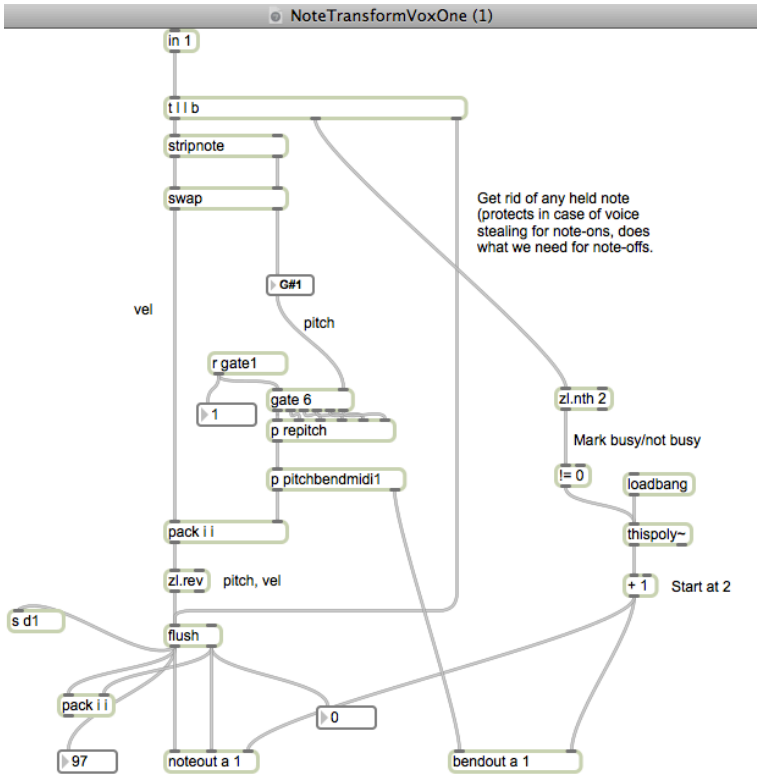

Figure B5: Inside the Poly~ *NoteTransformVox* object.

The *repitch* sub-patcher contains 'zl lookup' tables (Fig. B6) which is where the frequency sets or *scales* are stored. Each lookup table holds 128 values mapped from 0-127. The actual pitch-bending calculations happen in the *pitch-bend-midi* sub-patcher.

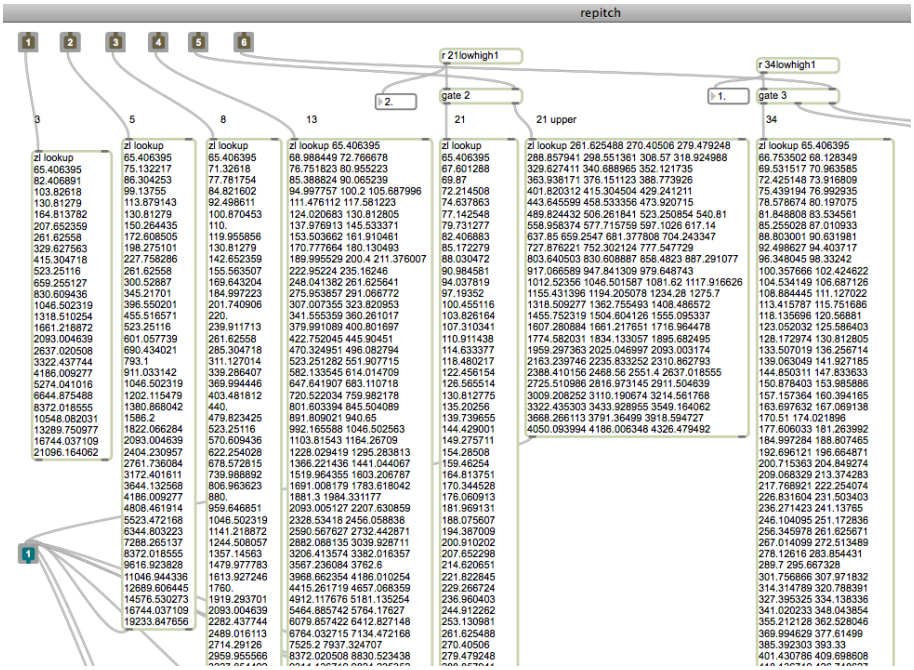

Figure B6: The *repitch* sub-patcher that contain 'zl lookup' tables with frequency numbers.

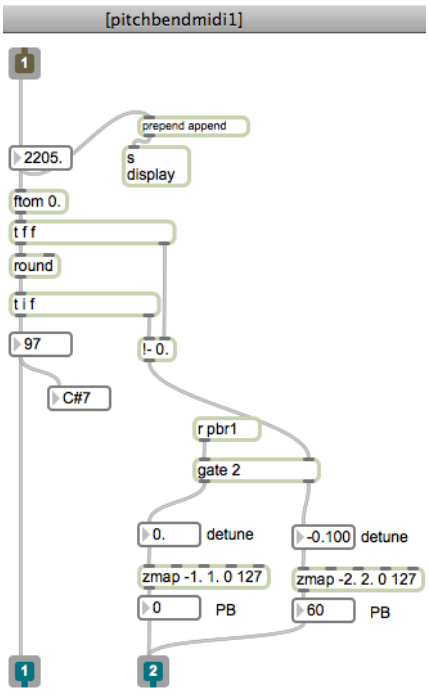

Figure B7: *Pitch-bend-midi* sub-patcher.