PHD RESEARCH PROPOSAL
SUSAN GREEN-MATEU

1. WORKING TITLE

Stitches in Time: Exploring movement patterns on macro through micro scales as an influence on my multi dimensional sonic art & composition

2. INTRODUCTION

My work is reconsidering and reimagining the interrelationship of large to small scale body movements and events as a more contemporary and multi-dimensional ideal on a timeline that started with Pythagorus' Musica Universalis and Keplers' Harmonices Mundi. The concept, analogous to a nested Matroyshka doll or the fractal architecture of the harmony of existence, is at the heart of my compositional exploration.

Throughout my Masters research I've found a correlation between the way in which movement theorist, Rudolph Laban explains the scaffolding of potential movement space around a body as being an icosahedron (which contains within it the preceding four Platonic solids) and the Kepler-Poinsot polyhedra, also known as (Johannes) Kepler's solids, that he used to explain elliptical orbits in our solar system. (Hart, 1996) "Kepler uses the term 'harmony' it is not strictly referring to the musical definition, but rather, a broader definition encompassing congruence in Nature and the workings of both the celestial and terrestrial bodies." (Field, 1983)

The five platonic solids also align Laban's theory of crystalline movement to crystal formation growth patterns in nature. These "…geometric rules allow Laban to allocate each one of these objects a specific function in the description of harmonic relations…this enables him to connect his theory of human movement with growth patterns in natural organisms." (Rudolf Laban and topological movement, Sutil) Parallels between the geometric patterns and properties of the movement of macro, mid-level and micro bodies/events, respectively, can be drawn and thus imbricated sonically.

3. AIMS

I will produce a portfolio of interactive sonic art works exploring the sonification and mapping of movement patterns from macro- to micro-body scales and sonic spaces. Levels may include: 1) Macro- orbital resonances of celestial bodies, 2) Middle- gross human body movements in relation to a stationary point or even around itself and 3) Micro- resonance on a cellular or particle level. The mapping of sound parameters will integrate both data and sonification of the resonance between specific objects or events, respective sizes, speed of motion and the trace forms made as representations of an acoustic timeline or time-spiral. Finally, works can be interwoven and superimposed in a synchronistic fashion to incite the perception of relative evolution. The multi-scale aural view will create a 3D sonic orrery journeying each level.

The work will be an extension of my Masters by Research which has been realised through the interconnection of multiple software tools. Throughout my MA I have utilised Ableton Live and Synapse connected through Max4Live patches using the Kinect as an external input device. I have also explored numerous sound spatialisation tools including the new MNTN software (https://mntn.rocks/). To realise my PhD portfolio I will extend my use of Ableton, Max4Live, Computer Vision and through more bespoke MAX and OpenGL programming.

4. RESEARCH QUESTIONS

- What is the audible outcome of the resonance between the movement of large objects? Small objects? Are there similarities/differences?
- Can the synchronistic mapping of movement patterns create a sonic timeline?
- How can Laban's macro-micro theories of universe-human movement patterns be utilised compositionally?
- Will the amalgamation of sonic timelines reveal a composite of a unified, flowing, multi-dimensional aural architecture of sound?

5. RESEARCH CONTEXT & LITERATURE REVIEW

This proposal will explore, in part, composition based on the sonification of orbital resonance of and other data sets for macro objects/events, middle objects/events and micro objects/events. It will examine synchronous mapping strategies as well as the overlay of pieces into a meta-piece in order to observe the possibilities of the auricular interrelation.

5.1 Sonification & Generative Music

"The heavenly motions... are nothing but a continuous song for several voices, perceived not by the ear but by the intellect, a figured music which sets landmarks in the immeasurable flow of time." (Kepler)

The research proposed is centered around the creation of works generated through the sonification of data. Generative and algorithmic music has made use of information and patterns to create works of sonic art and composition from the abacus to computer-age. There are many works available using this method of composition from Guillaume Dufay to Brian Eno and beyond. (Edwards, 2011) Below are some examples pertinent to this research project of how data sets on the three levels proposed have been sonified.

NASA has used generative sound made by the "audification" (Alexander, 2013) of macro or astronomical data sets and has been for some time now. Robert Alexander, a sonification specialist with the Solar Heliospheric Research Group at the University of Michigan, has worked with solar wind as an initial data set. In an interview with Thump/Vice he explained, "In the work that I do, I can pull out a whole load of solar data, maybe a solar flare, and you hear this kind of roaring lion, which is 'really' an explosion, so it makes sense to mutate it into an aural thing." (Baines, 2015) Marty Quinn, a sonification researcher at the University of New Hampshire has a project called: CRaTER Live, "…a streaming Internet radio station, based on particles impacting the Lunar Reconnaissance Orbiter's Cosmic Ray Telescope for the Effects of Radiation (CRaTER) instrument. The key, pitch and selection of certain musical instruments…in the spontaneous composition reflect the intensity of radiation bombarding the space probe." (Hadhazy, 2014) Each of these projects sonify data in different ways. Alexander used his program "Noteworks" (Fig. 1, 2010) to crunch data from a period of 10 years to produce the works. (Landi, 2012) While Quinn's project creates real-time music using real-time data. Both focus on one specific event or body.

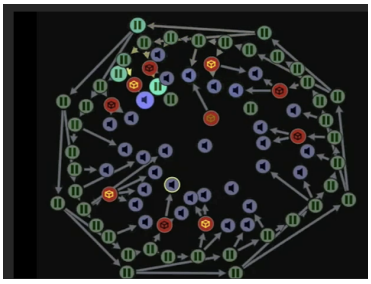

Figure 1: Noteworks (Alexander, 2010)

Micro and mid-level objects and events have also been sonified. Data that lead physicists to discover the Higgs Boson particle was used by Domenico Vicinanza to compose a piece of music in 2014. (Ouellette) For the 60th anniversary of CERN, he composed a piece performed by the LHCChamber Music Project," in which scientists performed a piece for strings, keys and

woodwind, based on data collected by the Large Hadron Collider." (Culpan) Kirk composed a duet for a violinist and sub-atomic particles titled "Cloud Chamber". He used a "sound interface called the Cloud Catcher. The Catcher tracks subatomic particle trails and uses them to drive certain control "knobs" on a digital sound synthesizer in real time." (ICCM, 2011) Hart made the Aurora Borealis come alive in his 4 minute electronic piece called *Sonification of Aurora Borealis*. "This sonification is based on the proton density and temperature of the solar winds, which are the source of the aurora borealis." (Hart, 2016) He mined his data from NASA's *Wind Carrington Tabular Table files* online to create an icy airy aural representation of the Northern Lights. Dunn & Clark sonified DNA by using data sets from DNA sequences. The "long multi-unit molecule containing Nature's digital code for life on Earth." (Life Music: The Sonification of Proteins, 2004) They used software by the name of ArtWonk to map various amino acids (aa's) and the solubility of them to pitches in one of two ways: fixed pitch for aa's or frequency histogram of the amino acids in the protein and assigning more consonant intervals ranging. They created what they called, "Solubility scales" that ranged over 3 octaves for diatonic scales, 2 octaves for chromatic scales and or 4 octaves for pentatonic scales. (Dunn, 2004)

5.2 Orbital Resonance, Elliptical Orbs & The Ephemeris

My proposal will investigate orbital resonance between objects and/or events as one of several routes to mine data to create works. There are two types of resonance phenomena:
1) Secular resonance which, according to Renu Malhotra in *Orbital Resonances in Planetary Systems,* "occurs when the orbital periods of two planets are close to a ratio of small integers" and
2) Mean motion resonance: "This is intuitively the most obvious type of resonance; it occurs when the orbital periods of two planets are close to a ratio of small integers." (Malhorta 2012)

Other information I will consider when sonifying data for the purposes of sonic art and composition can be velocity/speed, orbital period, energy, electromagnetic fields and interactions and elliptical orbs. Brackenridge discusses notes in relation to elliptical orbs of macro bodies such as planets in *Kepler, elliptical orbits, and celestial circularity*. (1982) In regard to our solar system in particular, each planet has a different shape of orbit around the sun. This accounts for its specific elliptical orb. Since Venus's orbit is near circular it was "found to be capable of only a single note" while Mercury, was said to produce the greatest number of notes of all the planets due to its very large elliptical orbit.

Some ways in which tones or intervals can be accounted for can be seen in Kepler's *The Harmony of Music* (1619), "Kepler found that planets did seem to approximate harmonies with respect to their own orbits. The maximum and minimum speeds of Saturn (measured in terms of arc seconds seen from the Sun) differed by an almost perfect 4/5 ratio (a major third). The extreme motions of Jupiter differed by a 5/6 ratio (a minor third in auditory space). The orbits of Mars, the Earth, and Venus approximated the following harmonies: 2/3 (called a "diapente") for Mars; 15/16 for Earth, or the difference between mi and fa; and 24/25 for Venus." (Kepler's *Harmonices Mundi*, Door to Science)

These approximate harmonies have been the basis for works like Alex Parker's *Kepler 11: A Six-Planet Sonata*. Parker sonified the star system Kepler 11 and its six observable planets. He explains his mapping strategy: "I've taken each transit seen by the observatory and assigned a pitch and volume to it. The pitch (note) is determined by the planet's distance from its star (closer=higher), and they are drawn from a minor 11 chord. The volume is determined by the size of the planet (larger=louder). The near-4:5 mean-motion resonance of the innermost two planets is audible as the notes 'beat' against each other." (Parker, 2013)

Obtaining orbital resonance and other figures or information for macro and micro bodies has been made readily available for the public to view and use. An example of this info for macro events is

the ephemeris. The ephemeris is a table that provides the calculated positions of celestial objects, such as planets, comets or other satellites, at any given day or time. On their webpage under *Solar System Dynamics,* NASA has provided several tool kits with data as well as applications to process the data sets. Some of these include HORIZONS system & NAIF SPICE toolkit which includes applications for various coding languages. (Park, 2001) The use of these tools and applications can be of great use when integrating data sets of this proportion.

On the middle and micro levels, resonant frequencies are the natural frequencies at which it is easiest to get an object to vibrate. A room resonance is a collection of frequencies that exist in a room related to the dimensions of the room. Using room resonance in composition and sonic art is not new. We can find examples from Alvin Lucier's I am sitting in a room (1969) through Michele Spanghero's Replay. She used acoustic space analysis by: audio recording of the resonance of the room: those frequencies excited the guitars generating feedbacks, whose sounds were modulated via computer and analog devices" (Inkono TV, 2013)

In addition to spaces, objects have resonant frequencies. If it is matched by an outside source (with little to no dampening) the object begins to vibrate at such a rate that it displaces and breaks. A notable use of resonant frequencies found during the review of literature is Anthony Holland's cancer research where he and his colleagues destroy cancer cells using only sound by matching their resonant frequencies and obliterating them in laboratory experiments. (White, 2011)

Some areas in which I plan to research further and incorporate into the works are relational angles and polyhedral shapes such as Kepler's Solids and Platonic Solids (As mentioned in the introduction). In the fourth chapter of *Kepler's Harmonies of the World*, he looks at the angles between planets at any given point in time. (Kepler, 1619) This is done by degrees around a central point. I plan on using the angles between bodies and events as a marker for intervals. For instance, a 90 degree angle, or square, between two objects could possibly be sonified as a 4th for instance. In the end, Kepler traded Pythagorean tuning in for "geometrically supported musical ratios; this would eventually be what allowed Kepler to relate musical consonance and the angular velocities of the planets." (Field, 1984)

5.3 Synchronous mapping of dynamics & Spatialization

Synchronous- Latin *synchronus* from Greek *sunkhronos*, from *sun-* 'together' + *khronos* 'time'

So far, over the course of my Masters by Research work at the University of Huddersfield, the focus has primarily been on Laban Movement Theory (Fig. 2) as a viable mapping system for movement or gesture to music. While it has been applied specifically to body movements, Laban, a consummate observer of the large and small was most likely attempting to map all movement based on his observation of human movement. (*Mastering Movement, the life and work of Rudolf Laban*, Hodgson) I am currently synchronizing movement parameters based on position, movement speed, durations, placement parameters to form a Laban Cube using Ableton, Max4Live, Synapse and a Kinect. It will be used to shape room resonance as well as content provided by live and recorded sound. Throughout the PhD research I will further experiment with applying the Laban Cube of movement to the movement of objects and/or events at the various levels of scale. Below is a simple break down of Laban's work:

Y axis- Weight (Gravity)

- Up = Light, Highs, Piano
- Down = Strong, Mid-Lows, Forte

Z axis- Time

- Frontward = Sustained, legato, reverb

X axis- Space

- Narrowing/Inward= Direct, centered, focus, dry signal
- Widening/Outward= Indirect, panning, delay, Specialization

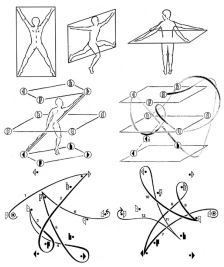

Figure 2: Laban Movement Theory

One project that seeks to map information from the physical sciences to movement is the *Genesis Music* project. *Genesis Music* is a collaborative effort between Biochemical and Molecular Geneticist Dr. Charles Strom and Professor of Art and Technology & Sound Dr. Peter Gena. They assessed DNA information such as molecular weight, hydrogen bonding, melting temperature to devise a "physio-musical formula" as well as a Max plug-in Gena called the DNA Mixer. (1999) They go into detail regarding their mapping methods over the course of 3 years of works and installations in *A Physiological Approach to DNA Music* regarding pitch/frequency, intensity and duration. (2001)

The research proposed will look into spatialization of the movements of bodies/events used in works created. On-going surveys of spatialization software and techniques are being conducted on a monthly basis. Programs include: MNTN, Timex, Dante Audio, Sonic Emotion and Zirconium. I have been working with IOU Theater for a new production, starting May 2017, that will be using directional locative audio headsets. Audience members will use these to listen to a binaural composition while traveling through the streets of various cities throughout the UK. The production is built on the concept of "acoustic heritage". (Murphy, 2016) Landmarks will be swathed in sound-memories. The technology is being worked on at the University of York.

In *Sonifying the Solar System*, Michael Quinton and colleagues conducted a listening experiment which included the sonification & spatialization of the solar system for a planetarium. "The resultant sonified model would be a sonic representation of 8 planets and their orbital revolutions around the listener who would be situated in the position of the Sun." The team used a program called Signification Sandbox to map multiple parameters such as volume, pitch, timbre and placement. They explain in their paper that xSonify, a software platform that transposes low frequency recordings of phenomena such as solar winds into the audible spectrum of human hearing, has lead to many audio-astronomy discoveries. (Quinton, 2016)

Jake Pember's work focuses on the exoplanets and orbital data from planets in distant star systems. He uses "orbital period data and the distance of each planet from the star to inform musical choices, and create interesting sonic textures through repetition and irregular rhythms." (Biomusic, Music in Nature and Musica Universalis, 2015) He seems to choose the keys arbitrarily yet has a system for pitch. The planets closest to their star (sun) have higher pitches in the key chosen than do planets that are further away. His method for data use is based more on day to rhythm cycles.

One piece from my Masters portfolio includes linking MIDI data from visuals in Isadora to Ableton Live while using the Kinect to gather OSC from movement. The data from the Kinect is mapped to various sound shaping parameters from kinesthetic movements based on the Laban Cube in order to shape the soundscape of visuals. For my PhD research, I will use the Kinect and Laban motion principles as a map for phsycho-acoustic audio, the Kinect or other motion capture device can act as an interface for spatialization and diffusion.

5.4 Overlap & Chaos

The research proposed seeks to compare and contrast, pull apart and superimpose compositions derived by coherent interrelationships to build each layer upon itself in order to experience the invisible scaffolding between divisions or dimensions. Overlapped works at various scale levels could possibly create an aural representation of unseen architecture. This macro to middle to micro overlay has great potential to produce sonic art and compositions that can be played in concert or individually much like jumping timelines. "The resonances found between orbits of planets and moons are an example of explicit and exact repeated patterns in all of nature." (Pember, 2015)

In *Orbital Resonances and Chaos in the Solar System*, Malhorta states: “The universal consequence of overlapping nonlinear resonances is chaos”. A theory explored to deal with the chaos of overlap is perturbed resonance. It is an analytical and numerical tool that takes the derivative of one set and the derivative of a differential system and is able to make small changes to the calculations to elegantly unify two seemingly different phenomena. This theory is used to resolve the orbital resonance configuration, as seen above in section 5.1 as such: “A secular resonance involves a commensurability amongst the slow frequencies of orbital precession, whereas a mean motion resonance is a commensurability of the frequencies of orbital revolution.” (Malhorta, 2012) the macro work created using planets (classical physics) can be played in concert with a piece that uses micro cellular or particle data (quantum physics). With this in mind the possibility of work created using planets (classical physics) playing in concert with a piece that uses cellular or particle data (quantum physics) can provide an aural understanding of how differential systems exist together.

James Gleick’s book “Chaos” delves into the genealogy of the science of finding order in chaos which leaves no discipline untouched. This includes sound and the way we can view the intricacies of interrelation. “Universality offered the hope that by solving an easy problem physicists could solve much harder problems…Something about theses functions must be recursive, [Feigenbaum] realized, self-referential, the behavior of one guided by the behavior of another hidden inside it.” (pg. 179, pg. 180) Overlaying pieces inspired by different scale levels will create an immersive experience interweaving everything from celestial to cellular counterpoint.

6. PLAN

I will create two to three works at each of the three scale levels: Macro, Mid-level and Micro. With every piece I will refine my mapping methods. Then overlay them to create a meta-work. My work will be inspired by and draw upon specific scientific models. Some of the produced works may be used for an educational project or installation at an Astronomy Magnet program and Planetarium in Miami, Fl.

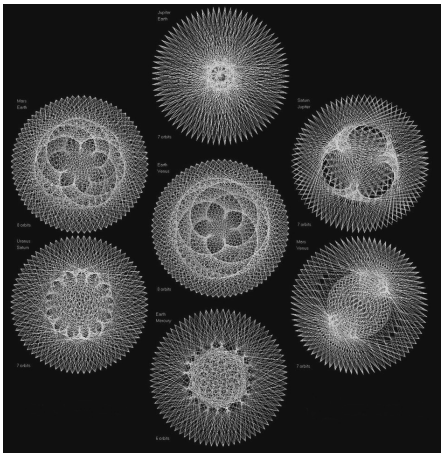

Figure 3: Duet Pieces- Two planet relative orbit patterns within our Solar System.

The first Macro piece I will work on will be “The Dance of Venus” where I will use the near-mean orbital resonance (duet pieces) between the earth and venus. The apogee points for thirteen of Venus’s orbits, in relation to eight earth orbits forms a five-petal flower shape. (Fig. 3, center image) I will use each planets individual resonance as a starting point for tone, respectively. I will continue refining mapping through creating a number of iterations of such duet pieces. Once duet pieces have been created they will be interwoven. I will also consult video models of each and use video data mining software such as Computer Vision Jitter to extract MIDI data. I plan on working with Ableton Live and Max for Live, as I have experience composing with these programs. Time, speed, distance data will be mapped dynamically in accordance with the above mentioned Laban Cube (Section 5.3), while taking into consideration a helical movement model of our solar system being sewn through our galaxy. (Major, 2016)

I will continue to modify mapping and sonification in a similar fashion through the mid and micro levels using software like Networks or bespoke Max patches. In addition to sonifying the interaction of bodies or objects, the proposed research will include events that involve communication or interface. An example of a mid-level piece could encompass working with conversation or interface with one another. The use of face-to-face conversations, email

correspondences and text exchanges as data sets are of interest. Parameters will include: tone of conversation, frequency of response, duration of exchange among others. These conversation pieces will be overplayed and interwoven as above. As for the micro level: DNA structure and DNA Replication are promising data sets to sonify. The double helix pattern can be mapped much like the solar system. Amino acid pairs can be mapped similarly to planetary duets. The origami unfolding and unzipping of and the intricacies of RNA produce are all viable data sets available to sonify. Visual work will be done through a combination of various programs including: Blender, Jitter, Quartz Composer, Isadora and Millium (a projection mapping program).

Finally, I will explore the possibility of an overarching meta-composition unveil consistencies and contradictions throughout the scale levels. Dynamics and spatialization will act as an aural zoom function. A journey through the intricacies of the macro to the micro and back again without telescopes or magnifying glasses may be experienced. In a live performance setting the use of a motion tracking device, like the Kinect, mapped to a program such as MNTN will allow the performer to diffuse and pull out various aspects of the whole over the HISS system. In recorded pieces, mixing will be done binaurally for spatialization as sonic art. Each individual piece will be whole in and of itself yet, will find its place within a much larger architecture draped in the interwoven fabric of its own voice, stitch by stitch.

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