

Co-Composition and De-Composition; Biological agency as a compositional tool.

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Abstract.

This paper examines a series of creative sound-works which combine human and biological agents to re-mix, create and re-invent musical scores. The central concept is to consider Genes, Memes and Musical notation as parallel mnemonic structures that function as instructions for the fleshing-out of life across temporal barriers.

GeneMusik and associated works *Under the IceCap* and the *Quartor pour la fin du temps à l'Escargot*, are generative processes where the outcome is surrendered to biological agents, but which operate within a broad combinatory framework of cultural, social and biological pathways.

The stochastic process of biological transformation which erode the human agency invested in authorship is however returned to the human sphere as performance and the nuances of interpretation and virtuosity. The final example *Oratorio for a Million Souls* differs in that the musical scores are created not as a symbolic representation of a biological system (Bee colonies) but as an indexical interpretation of actual acoustic and sensor data. [1]

Keywords.

Art and Science, Art and Biology, Music and Genetics, Experimental Music, Micro Performance.

Introduction.

The paper will examine five test cases that share overlapping creative methodologies, but which have been developed in varied geographic, biological and cultural contexts. Each work relies upon a co-creative relationship with living organisms to generate the basis for musical structures, as in the collection of deep ocean data by southern elephant seals in *Under the IceCap*; or the harvesting of hive data and audio from bee colonies in the *Oratorio for a Million Souls*. Other works function to create structural modifications of ex-

isting musical scores at the level of the micro-organism in *GeneMusik* or in the gradual erosion of a well-known work by Gastropods in the *Quartor pour la fin du temps à l'Escargot*.

Under the IceCap and BioLogging Retrofit.

Science is constrained by Objectivity and Impartiality, and perhaps Art is constrained by Subjectivity

We start our *Bio-Sonic* journey by heading toward the South Pole and the Sub-Antarctic islands. *Under the Icecap* is a long-term Art and Science collaboration between Artist Dr Nigel Helyer (Sonic Objects; Sonic Architecture) and Marine Scientist Dr Mary-Anne Lea (Institute for Marine and Antarctic Studies at the University of Tasmania) that links scientific bio-logging data and GIS techniques with interactive acoustic cartography and the development of *AudioPortraits* that extend the conceptual and intuitive grasp of extremely abstract bio-logging data.

The byline for the Institute of Marine and Antarctic Studies is *Turning Nature into Knowledge*. The *Under the IceCap* project supplies a second line *Turning Knowledge into Culture* encapsulating a powerful Art and Science synthesis and simultaneously raising the expectation but also the risk of the endeavour. The primary aim of the project is to produce creative works which are compelling and affective, but which is simultaneously can be a work of scientific utility; hopefully tapping into both sides of the brain! The key focus is to illuminate the relationship of the environmental knowledge generated from Antarctic bio-logging data with the Anthropogenic changes in the biosphere.

The collaborators realised that the extensive and extremely complex datasets collected by southern elephant seals (*Mirounga leonina*) repre-

sent a considerable interpretive challenge and provided the opportunity for a hybrid art and science exploration of new methods and forms for manifesting the data and to develop novel forms of public awareness and debate about the Oceanographic and Climatic data that the seals collect.



Figure 1. Southern elephant seals with the latest in bio-logging data-chic ©IMAS University of Tasmania.

Our aim is focussed upon developing techniques for visualising and sonifying the complex bio-logging data collected by Southern Elephant Seals on their deep dives under the Antarctic Ice shelves and their long Southern Ocean transits. We explore new ways to make these data-sets palpable, manifesting them as a series of experimental music concerts and visual and sonified installations with the express intention of illuminating the fundamental connection between human activities and planetary dynamics.

The intention that drives our methodology is that the artistic and scientific paradigms which intersect in *Under the Icecap* form the basis of a robust and productive trans-disciplinary collaboration. The word collaboration is widely and often incorrectly used in art & science projects, typically one discipline being subservient to the other. However, the emphasis within *Under the Icecap* is to design an open, consensual and collective creative research process, that balances and complements the knowledge bases, motivations and target audiences of the art and science disciplines involved.

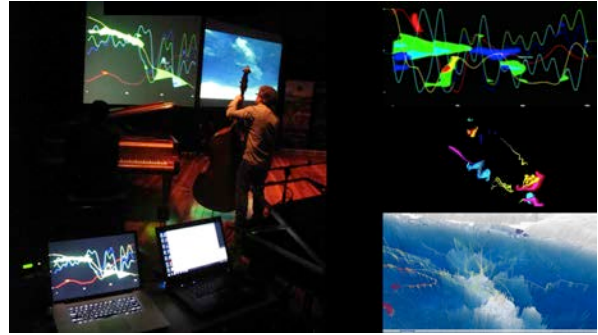


Figure 2. A performance showing data generated animated graphical score and 3D maps ©The Artist.

Within a scientific context such bio-logging data is most frequently consigned to two dimensional graphs each of which contains a limited range of variables, making a wholistic *gestalt* improbable, if not impossible to achieve. Searching for a more flexible approach we imagined a situation in which each of the many variables could be dynamically put into play, examined in real-time and generate on the fly responses - a kind of neural network. Our solution, musicians! Our decision to interpret environmental data via an aural process is based upon a hunch that musicians have the best pattern-recognition *wet-ware* around and that our aural sensibility is in fact more finely tuned to detect minor variations in pattern and recognise subliminal differences, than our visual sense.

The large multi-factorial data sets are reconceptualised in two ways. Firstly, using a sophisticated cartographic software, we generate animated 3D maps of the data traces of individual elephant seals for large scale data-projection. Using exactly the same data we also generate various forms of graphical scores and again render these as dynamic projection works. These are then presented in parallel to a quartet of professional musicians in a live concert context where they are asked to respond individually and/or collectively to the material (there have been many structural variations on this method).

Naturally the elephant (seal) in the room is the scientific allergy to a subjective, and non-repeatable response which some may consider renders the enterprise interesting but ultimately unscientific. A somewhat cheeky rejoinder might be that statistical data is, in and of itself, an artefact and

that its analysis is even more so. Does the bio-logging data in any manner resemble the experience of a southern elephant seal feeding at two Kilometres deep beneath an ice shelf at a pressure of one hundred and ninety-four atmospheres? As the British Prime Minister Disraeli once said.

*There are three kinds of lies;
lies, damned lies and statistics!*

IceCap [Archive files here](#)

BioLogging - Retrofit.

As a trained sculptor it is not unknown to get itchy fingers after hours gazing at spreadsheets and data animations. As an *Entr'acte* I decided to repurpose these complex data placing them in the context of the pre-history of computing; the punch paper cards that controlled early musical automata and which subsequently influenced the development of the Jacquard loom; the Hollenzoller machines; IBM *et al.*

Using the identical data that had driven our large-scale animated cartographical projections and graphical scores I laboriously transcribed each data point, punching note by note into the paper rolls, of the four thirty-note music boxes, each equipped with an acoustic horn. The four extremely long and unwieldy rolls collated Surface Wind Speed, Depth with Salinity, Depth with Temperature and Ocean Bottom with Bottom Density.

These anachronistic music machines were destined for a debut performance at the *Australasian Computer Music Conference 2015*, University of Technology Sydney and subsequently the *International Computer Music Conference 2016*, at the University of Canberra. Needless to say, within the context of the ICMC this crude but effective Digital to Analogue sonification of data was a touch the earth moment, as it made palpable the black-magic of statistics and spoke to the deeply physical roots of computation.

BioLogging [Archive files here](#)

GeneMusiK, from large creatures to microbes.

GeneMusiK is an experimental biological music system that puts into play the parallels between

Genes; Memes and Dots (musical notation). The concept is to establish a functional relationship between conventional Western music notation and DNA sequences - facilitating a method to mix and mutate musical forms within a biological domain.

Whereas previous work in this field has generally interpreted known DNA sequences into musical analogues, *GeneMusiK* makes a radical departure by inverting this process and proposes an entirely organic process, employing chemical and biological means to transform music into genetic material and back again.

GeneMusiK takes short sequences of melody and rhythm and converts them into DNA sequences. These are synthesised and inserted into the plasmid DNA of *E. coli* bacteria which is cultured and subsequently mutated by chemical or other means (for example UV exposure). The mutated DNA extracted is then from the bacteria to be re-sequenced and translated back into standard musical notation forming novel musical forms for performance.

The essential conceptual direction behind this activity is to consider biological codes and musical codes as structures capable of reproducing themselves over time and which are also amenable to adaptation and evolution - in other words both forms possess the ability to manifest themselves from a stored core of *memory* but a memory that is subject to deformation, re-interpretation, and the transmission losses that we experience as the physiological, political and social *Chinese Whispers* of historical revisionism and socio-cultural change.

My approach has been to use these powerful metaphors of memory and amnesia to create a remix of popular cultural forms (music) using biological vectors (bacteria) which are manipulated to produce variations or mutations and in which the concept of performance occurs in both the microscopic and macroscopic register.

This work is mindful of two related views on memory. Our own memory processes are mediated by, or indeed dependent upon, a physical sense of and orientation within space - our memory is structured around associative triggers, often sensory experiences, odours, sounds and mu-

sic but also physical structures; buildings; the landscapes and topography.

Geographic location has been identified as a central feature in the processing of memory, managed by the Hippocampus, which employs a complex network of Place; Grid and Border cells to situate spatial memories. Thus, our sense of place (of space infused with meaning) is a product of the deep neuronal structures within our brain that perform an analogical linkage between real-world loci and our internal physio-electro-chemical spatial coding.

The second reference that combines the physical site and morphology is the regular spacing of foreign genetic material found in microorganisms such as archaea and bacteria. These spatial sequences originally discovered in 1987 are now known as CRISPR. (Clustered regularly interspaced short palindromic repeat). At its simplest (sic) fragments of the genetic sequences of aggressor organisms (phages etc) are incorporated in regular repetitive sequences within the DNA of bacteria (etc) and function as a type of immune system - in effect physically incorporating a memory of a previous assault.[2] [3]

Einer Kleiner GeneMusiK. Prototype No.01

In 2014 the *VryFees Festival* in Bloemfontien, South Africa invited me as an artist-in residence to re-develop the *GeneMusiK* project (first conceived of in 2003 at the *SymbioticA* lab at UWA). Based between a micro-biology lab and a music conservatorium. I worked with indigenous South-African San musicians who live in the bleak re-settlement camp of Platfontien, some two-hour drive to the West, near Kimberly in the Northern Cape. The aim being to hybridise local ethnic music via a transformative biological process with the with the epitome of the western musical tradition, a string Quartet from the University of the Free State, Odeion Music School.



Figure 3. Master Jasheel in Platfontien, S. Africa ©The Artist.



Figure 4. A restrictor enzyme map of the DNA representing the San Gorah score ©The Artist.

During my sojourn in Bloemfontien, the project established a successful prototype of all the functional components that comprise the complex chain of transformations - taking audio field recordings (of San musicians) via audio analysis into musical notation, thence into DNA and then into Bacterial culture, to subsequently be cultured, mutated, re-extracted and ultimately rendered as scores for musical performance.



Figure 5. A San bushman playing the Gorah from *Travels in the Interior of Southern Africa* by J.W. Burchell (1810).

On my research travels I was fortunate enough to uncover a unique early transcription of San music discovered in an explorer's publication from 1810. W.J. Burchell was a British polymath, scientist, botanist, musician and intrepid traveller and it was in his publication *Travels in the Interior of Southern Africa* that I came upon an illustration of a seated San Bushman playing a mouth bow (Gorah) accompanied by a musical transcription. [4]

Using this simple score as an additional source of musical information a complimentary DNA sequence was generated and as before, the action of restriction enzymes was used to fragment the DNA code. The re-assembled fragments generating another set of novel sequences which were incorporated with the contemporary San content and merged into a final composition which was given to the Odeion String Quartet to play. The result from the initial rehearsals - a complex and

challenging work and certainly not easy listening! These results were however produced via genetic modelling (i.e. *in-silica* - rather than *in-vitro*) as I had mis-calculated the timescale (and costing) of the micro-biological work in the laboratory (i.e. I simply ran out of time and money).

GeneMusiK - Over the Rainbow.

Prototype No.02.

However, in 2016 *Cultivamos Cultura* in conjunction with the *Instituto Medicina Molecular* in Lisboa invited me to their *Ectopia* programme to attempt the method again. Using the very simple melody of *Somewhere over the Rainbow* I tried several times to render the score as viable DNA sequences but encountered ongoing problems in which the DNA clotted due to the exceptionally repetitive nature of the Codons in the DNA sequence - when quizzed by the DNA synthesis lab I had to explain that they were coding music which naturally contained a lot of repetition!

The conversion-table was re-written multiple times and eventually I decided to work with the score and lyrics at the level of the bar, rather than the individual note. This compromise paid off and for the first time the project went through the entire biological life-cycle, producing fifty sets of mutated DNA sequences - several of which have been laboriously transcribed by hand back into music score. Of these two have recently been successfully rehearsed and performed by a singer and pianist.[5]

In general, transforming the score at the level of an individual note tends towards highly abstract formulations, containing only an occasional familiar melodic sequence. However, working at the level of the bar produced an interesting performance effect - in which the score was *quantised* into bar sized units but recombined in abstract patterns. The issue for the performers was their familiarity with the original melodic structure in an encounter with a new version, now one full of non-sequiturs, repetition, inversions and octave changes that countermands the memory of the original work.

GeneMusiK [Archive files here.](#)

Quartor pour la fin du temps à l'Escargot.

Finally a slight change of direction, whilst the outcomes of the complex micro-biological processes of GeneMusiK resembled a cosmic game of roulette and required a laboratory (as costly as a Casino) I realised that fundamentally my interests were in combining the strict order of musical composition and notation with a stochastic process, in which I might be the originator or catalyst but certainly not the Composer or the Conductor.

Back in the sub-tropical climes of my Atelier in coastal NSW (Australia) I discovered that the local species of snails had an insatiable appetite for the letters in my mailbox.

I had recently installed a public-art soundwork *A Dissimulation of Birds* a series of acoustic bird-houses which counterposed avian mimicry of human sounds with human mimicry of birds and which featured Messiaen's *Catalogue des Oiseaux* a work which resonates with his work fifteen years prior, which is also informed by his interest in birdsong.[6]



Figure 6. *A Dissimulation of Birds* installed at the Bundanon Trust NSW Australia 2017 ©The Artist.

And the angel which I saw stand upon the sea and upon the earth lifted up his hand to heaven. And swore by him that liveth for ever and ever, who created heaven, and the things that therein are, and the earth, and the things that therein are, and the sea, and the things which are therein, that there should be time no longer.

The *Quatuor pour la fin du temps* was written whilst Messiaen was a Prisoner of War in Stalag

VIII-A, located in Görlitz, lower Silesia (now Poland) and performed by his fellow prisoners. Stalag VIII-A was by no means the stereotypical extermination camp - whilst the camp operated with a frugal wartime regime, Messiaen and his colleagues were however assisted by the music loving German officer Karl-Albert Brüll and afforded special privileges and indeed encouragement. For instance, Messiaen was given light duties very early in the morning in order to indulge his interests in the bird-song of the dawn chorus and even had a guard posted at the door of his hut to prevent disturbances whilst he composed. The *Quatuor* was performed only once, as just one month later Messiaen was granted an early release from prison, facilitated by Karl-Albert Brüll who provided him with forged papers reclassifying him as non-combatant.

I thought of the *Quatuor pour la fin du temps* and how the work was written under extremely difficult wartime circumstances, about its dysjunctive structure and its register that is steeped in apocalyptic religious mysticism, but which is also strongly connected with the redemptive power of nature. Might this work also be transformed by a process of biological entropy as a means of metabolising its meaning, to perhaps offer a sombre reflection upon the increasing militarism and political oppression that the cataclysm of 1939 ~ 1945 failed to erase and which haunts us still in the form of Xenophobia and racism?



Figure 7. *Quatuor pour la fin du temps à l'Escargot* in process.©The Artist.

In section three of the Quatuor, the *Abîme des oiseaux* Messiaen writes:

The abyss is Time with its sadness, its weariness. The birds are the opposite to Time; they are our desire for light, for stars, for rainbows, and for jubilant songs.[7]

It may be that *Time*, the time of history and of culture had indeed ended in the conflagration that surrounded him, and the internment which in his own reckoning was his fate. But perhaps time in its historical form had already been obliterated in the previous European apocalypse of 1914~1918. Perhaps the Angel that proclaimed time is no more (the abyss) is simply a cultural figment – and that the time of birds and microorganisms continues to resonate at different frequencies.

The Hive Mind.

Oratorio for a million Souls provides a conclusion to this series of co-creations. Whilst this triple-site public-art project was designed to contribute directly to the debate around issues of bio-diversity and the population collapse of bird and insect species in Europe, the decision to work with bees developed from a long standing interest in the cultural metaphors that have historically been associated with colonial insects (especially honey bees). The organisation of the hive with its epigenetic formation of social ranks and the strict division of labour, have long been used as a template for human social and political regimes. Characterised as obedient, efficient and with a selfless devotion to the common cause, bee society has been a paradigm vaunted by autocracies and monarchies for centuries; only recently has research demonstrated the remarkable level of consensual decision making that rewrites the old hierarchical stereotypes.

A second strand of interest is focused upon the complex abilities of communication, navigation and collective problem solving that is performed not by each individual, but as a network – the *Hive-Mind*. Far from the original *rule from above* model the level of parallel processing and complex communications evolved by bees over 100 million years render the hive as a true *Super-Organism*.

It was in this context that the *Oratorio for a million Souls* developed three bee-listening architectures sited in European botanical gardens, each structure equipped with two sensor hives. As the work is extensively described in the proceedings of ISEA2019 this article shall focus upon the creation of musical scores, external to the public artworks *per se*.

Working closely with my colleague Dr Jon Drummond we were able to take two streams of real-time audio from the sensor-hives; from miniature DPA microphones embedded in the entry and exit ports of each hive and from custom built contact microphones placed deep within the hive itself. The audio content was complimented by data extracted from a series of hive exit and entry sensors that provided a picture of the diurnal activities of bee colonies, which generally correspond to external temperature and light levels.

We used the audio recordings to establish a tonal palette that was subsequently quantized into an even-tempered scale. The bee movement data was parsed into a rhythmic and temporal framework, giving the score its overarching structure.

In contrast to the more stochastic processes of the previous works once the ground-rules were established the musical form took on a life of its own, bound by the parameters derived from the original hive audio and data. The resulting scores were, from the perspective of the three large brass and wind ensembles, quite unconventional and challenging to play. The performative challenge was amplified by the technical and logistical difficulties in synchronising the three-part score via an audio-visual satellite link-up that connected the botanical garden in Buitenpost (Netherlands) with gardens in Emden and Oldenburg (Germany). The outcome of the debut performance which launched the overall project, was a success, despite the inclement weather which drizzled into the mouths of Tubas and Bass Saxophones – a tribute to the hive-mind of the musicians, conductors; sound-engineers and cultural-producers – it seems that we may have learnt something from the bees!

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- [5] see [FAACT 2018 exhibition tour](#).
- [6] see: [A Dissimulation of Birds](#)
- [7] The New Testament, Book of Revelation (Αποκάλυψις).

Author Biography.

Dr Nigel Helyer; an internationally prominent sculptor and sound artist is a contemporary polymath whose interdisciplinary practice combines art and science to embrace our social, cultural and physical environments. He brings these concerns together in creative projects that prompt the community to engage with their cultural histories, identity and sense of place; inviting us to examine the abstract conditions of our world and our complex relationships to it.

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