Resonances III

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European Commission

DATAMI: a data tatami that restores our capacity to freely develop our expanding identities, but also a shelter and a refuge against the data deluge and digital transformation: ataraxia in a digital whirlwind, harbinger of a digital declaration of independence, constituent of the Magna Carta of the Web.

European Commission

Joint Research Centre

BOZAR

CENTRE FOR FINE ARTS BRUSSELS

UNTIMELY EULOGY MARIA REBECCA BALLESTRA

Maria Rebecca Ballestra will forever remain the epitome of climate change awareness. She wholeheartedly embraced and was constantly renewing Datami's legacy. Through her creativity and indefatigable energy, she promoted positive transformation in science, humanities, economy, ecology and art. Her long-term project *Echoes of the Void*, investigating the geological, cultural, spiritual and environmental meaning of the world's wastelands was awarded the *CMCC Climate Change Communication Award in 2021*. The award was renamed *CLIMATE CHANGE COMMUNICATION AWARD Rebecca Ballestra* in her honor in 2022 guaranteeing that her spirit will forever animate our environmental work.

Freddy Paul Grunert

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RESONANCES III: the flagship programme of the JRC SciArt project. Driven by a DIY philosophy, it brings together scientists, artists and policymakers in a two-year cycle on a theme central to the work of the JRC and the European Commission. In the first year, participants establish dialogues and look for commonalities of intent in a summer school, geared towards the co-creation of novel works of art nurtured by science invigorated by art and society. In the second year, the works are realised in a close dialogue between artists, scientists and policymakers, unveiled in a festival on the JRC Ispra site at the Lago Maggiore, Italy, then presented to the European public in major venue. Bridge, island of negentropy, the Resonances Festival and Exhibition is an experiment in dialogue, public discussion, rapprochement of knowledge and society, an active sign of union in a union of equals, an exercise in and invitation to a true democracy of disciplines. As any good experiment, it has no fear to fail.

Big Data

Computing [also with capital initials] data of a very large size, typically to the extent that its manipulation and management present significant logistical challenges; [also] the branch of computing involving such data.

Artificial Intelligence

The capacity of computers or other machines to exhibit or simulate intelligent behaviour; the field of study concerned with this. Abbreviated AI.

Digital Transformation

Digital transformation is the profound transformation of business and organizational activities, processes, competencies and models to fully leverage the changes and opportunities of a mix of digital technologies and their accelerating impact across society in a strategic and prioritized way, with present and future shifts in mind. Digital transformation is not just about disruption or technology. While digital transformation is predominantly used in a business context, it also impacts other organizations such as governments, public sector agencies and organizations which are involved in tackling societal challenges such as pollution and aging populations by leveraging one or more of these existing and emerging technologies. In some countries, such as Japan, digital transformation even aims to impact all aspects of life with the country's Society 5.0 initiative, which goes far beyond the limited Industry 4.0 vision in other countries.

From: https://www.i-scoop.eu/digital-transformation/

Resonances III

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DATAMI: a manifesto

Big Data have erupted in our daily lives. What are these big data, this artificial intelligence - with their promise of digital transformation - that we choose to fear and exalt in equal measure? In order to address these issues, we have translated them into a new concept, that of Datami: it helps us to think about them in all freedom, as a way of bringing these exalted subjects into our own more common life, closer to what we really want. We see the *Datami* as a virtual tatami, made of the data that we cherish, our data and those of our families and friends, our discoveries and curiosities, our roaming and conversations, all of these making up our new identities. In real life, our Datamis are being created with each new conversation, each interaction and each payment, our digital trail acquiring substance in the databases of all companies, big and small, digital or not. But these are our data that reflect our personal lives and we need them to practice our freedoms. That is why we conceive the Datami as a data tatami, a place of rest and repose against the digital onslaught, a maker-space of embodiment.

It must help us restore our capacity to freely develop our expanding identities and claim our own digital trails. To investigate the emerging realities around us with all the powerful means of modern media – truly a paradise of information! There, discipline blends with intuition, science with art, imagination with rigour and image with meaning, all bundled into a new language of collaboration. Someone has invoked the term artonaut (Freddy Paul Grunert, 2018) to describe these new figures capable of straddling different disciplines and addressing our wicked problems, talking at once to scientific labs, industrial workshops and artistic imaginations.

But we know this paradise is also flawed, a constrained surface, so our Datami must also become a shelter and a refuge against the data deluge, against fake news and the mounting fears for the digital transformation: eye of the storm, ataraxia in a digital whirlwind, harbinger of our digital declaration of independence, constituent of the Magna Carta of the Web that we all feel coming, as the winds of change also ruffle our digital lives.

The challenge of the Resonances III on Big Data is to elaborate this personal Datami in a common endeavour with individual results, including the inevitable glitches of the digital, so that each of us can reap its benefits. This work must be able to conflate all disciplines and insights in a collective effort with a myriad of individual threads. It is not limited to art, or to science, or to policy, to culture or to society, but capable of englobing and connecting them all, dense in identity as any person walking in the street. It reaches out to the future from a new and enriched on-life. Not on- and offline, but permanently entering into a digital sphere, a new on:life. Penetrating this sphere is a common endeavour resulting in a new kind of work, which cherishes the hybrids, cross-overs and collaboration of the digital as a collective opera, a new form of work with new room to explore and bring to fruition the spaces opened up by the internet and open source. We propose to call this extended concept of work opera, from the Latin opus, a singular plural, liberated from formality and prejudice and capable of tapping into new forms of creativity, a crea-connectivity, in a free democracy of disciplines.

This too is Datami: coming together as citizens to probe deeper into this hyped and uncertain future, declining our new identities. Opening and closing the digital walls of our Datami as we choose or as need dictates, in a continuous dialogue with our surroundings. Whatever these may be, looking for opportunities to discover new facets of our beings. Our data are ours.

It is an effort. It is collective. It is open and uncertain. It can never be defined in isolation.

In short, it is democracy.

Let's do it together.

Introduction

Adriaan Eeckels, SciArt Project Leader

who cares if some oneeyed son of a bitch
invents an instrument to measure Spring with?
e e cummings

On Big Data, AI and JRC

Big Data is ubiquitous and elusive. They have grown explosively in the last ten to twelve years[1]. The amount of stored data grew to more than 4000 times its size between 2006 and 2018, and is now expected to double by 2020[2]. Attention to the phenomenon has grown too, with numerous articles and books denouncing dangers, risks, and opportunities. Nick Bostrom warned against the creation of any superintelligence in 2014[3]; Cathy O'Neil denounced the evident biases in many AI systems used to grant loans or calculate recidivism of prisoners[4] in 2016, and in May 2017, *The Economist* declared that data was the new oil, "… A new commodity [that] spawns a lucrative, fast-growing industry"[5]. Then came the realisation that Big Data allows for fake news to target and manipulate individuals, as during the Brexit and US campaigns of 2016, followed by the Cambridge Analytica scandal. The latter broke out in March 2018; and only two months later the company closed operations. Since then, attention to Big Data and their misuse has peaked. A growing chorus of former employees of the big five Internet companies, NGOs, journalists and academics denounce the disrespect for privacy and call for a better control of the commercial use of personal data. A direct indication of the changed attitudes to Big Data is the consideration for the new privacy regulation of the European Commission, the so-called General Data Protection Regulation or GDPR[6]. Before the Cambridge Analytica scandal, in the autumn of 2017, the GDPR was disapprovingly discussed by many American pundits, companies and politicians. However, when it entered into force in May 2018, after the scandal, opinions had shifted and it drew admiration and recognition from the same commentators[7]. This also became clear from the testimony of Facebook CEO, Mark Zuckerberg, to the American Congress, followed with big clamour by the press. The resulting hearing was deemed unsatisfactory, as Mr Zuckerberg's answers were considered evasive and elusive, failing to address, not answering to the real issues, such as theft of personal data and the way data are used for targeted advertisements, either with the Members of the US Congress[8] or those of the European Parliament[9].

Today, the rich and famous too talk about Big Data, AI and the singularity, from the late Stephen Hawking and Elon Musk to George Clooney and Madonna. The rapper will.i.am coined the term ‘idatity’ as a contraction of identity and data, declaring that personal data should be regarded as a human right, in the same way as access to water[10]. Tim Berners-Lee, co-inventor of the Internet, has developed a new protocol called *Solid* (for Social Linked Data), a “technically potent open-source platform built to decentralize the web”. It is based on the principle that “users should have the freedom to choose where their data resides and who is allowed to access it.”[11] Berners-Lee hopes to create a new, improved internet with Solid, reinforcing the *Magna Carta of the Internet* developed with children in 2015[12].

Big Data are now used everywhere, from computing to a host of scientific disciplines like climate science, meteorology, physics, engineering, etc.; for the prediction of the stock market to machine translation, for weather forecasts and stock management, for the development of new proteins and new materials to criminal justice and art. It is not an exaggeration to say that everybody uses them – not only computing, science or business, but also governments and, more and more, designers and artists.

With Big Data comes Artificial Intelligence (AI) and the Digital Transformation. The recent success of AI depends on the availability of huge amounts of data that can be crunched by dedicated software on powerful computers. The concept of an artificial intelligence is nearly as old as the first computers, but the idea that humans would create an intelligent creature, automaton or alive, is as old as antique civilisations, as shown in a recent exhibition at the Barbican[13].

The term *Artificial Intelligence* was coined in 1955 by one of the pioneers of computer science, John McCarthy, who defined it as “the science and engineering that tries to make machines intelligent,” where “… The ultimate effort is to make computer programs that can solve problems and achieve goals in the world as well as humans”[14]. The Pioneers McCarthy worked with were convinced that machines would be capable, within twenty years, of doing any work a man can do[15]. This turned out to be more complicated than expected, and the field entered what AI researchers themselves call the “AI winters” of the 1970s and 1980s. This period of slack ended when the step-based approach that had hitherto characterised programming, moved towards artificial neural networks. These function in a mode that is somewhat akin to biological networks. Special algorithms can update the relative weights of results and thus refine them. This allows programmes to learn from the data and the outcome of previous calculations and improve without having specifically been programmed. When this is applied on more than one level, it becomes deep-learning. The great development of AI from 2005-2010 in refining and combining these methods provoked a massive commercial application from various dedicated AI systems from the year 2010 onwards, starting with Apple's voice assistant Siri in 2011. Often, successful AIs combine symbolic or rule-based AIs (like Deep Blue, who beat world champion Kasparov at chess in 1997) with data-driven AI, which use great quantities of data to learn (like Google's AlphaGo machine that beat the world champion of Go in 2016).

By now it is clear that together, Big Data and AI are driving what many see as the digital transformation of our work, our societies and our lives. Many applications are already being tested or in use, from self-driving cars to decision-making assistants for the medical world, from connected fridges to facial recognition used to regulate access to buildings or for customs. Our houses, our cities, our jobs, our mobility, our leisure, our energy, our systems of governance and even our democracies are all expected to change fundamentally under the influence of this global transformation, deeply influenced by a rising climate emergency. There are many opportunities to these changes, but also many unknowns. How many jobs will be lost? How many created? What about our social protections? Will our societies become fairer or not? And what about our data?

Even in the age of bewilderment[16], a casual observer might be bewildered by the rapid rate of change and the challenges we are confronted with. We are overwhelmed by information overload; yet we seem to know more about climate change – still thought to play out its worst effects later in this century – than about this digital transformation, which might play out in the coming ten years with equally profound consequences for our societies. While the so-called populists claim an antiquated nationalism and a newly self-confident Alt-right falls back on a traditional past of doubtful contours, we seem particularly unprepared to grasp the impact of this coming transformation and to prepare a vision of how to deal with it collectively. Yet like climate change, this transformation knows no borders and the eventual disruptions will play out on a global level. In other words, it reinforces the fundamental reasons for the European collaboration, at a moment that the European project is still under fire from many different angles.

As a transversal European Commission service, with the mission to provide science and knowledge for sound and robust EU policies today as well as in the near and distant future, it is the responsibility of the Joint Research Centre (JRC) to think ahead and outside the box. With the rapid pace of change, the information overload, the looming digital transformation, the existence of societal challenges such as climate change, migration, fake news, political polarisation and growing culture wars now arriving in Europe too, the solution

Resonances III Datami
Hall of Building 100
Festival JRC Ispra site,
15 October-8 November 2019,
Photo Jill Townsley

cannot be to carry on in the same way. The JRC builds on the understanding, that in our shape-shifting world, it must make a special effort to stay with the times and fulfil its mission.

The SciArt programme

The SciArt programme, established in 2016, is one of the new initiatives of this new direction the JRC has taken. SciArt is science, art, and society: the SciArt programme brings together artists with JRC scientists and EU policy-makers, in a space of dialogue that can bring both research and art closer to society. The assumption is that *artists are the antennae of the race or the canary in the coalmine*[17]: they can help JRC researchers to better understand and respect the worries of the citizen. Within the framework of the project, researchers, policymakers and artists meet, discuss, but most of all, they have the possibility to start collaborating on artworks inspired by science that in its turn, is invigorated by art. The first objective is to bring innovation to research, in order to answer the question posed by Michael John Gorman "… whether such art can alter the direction of scientific research"[18]. Can it? How can it bring about innovation? One of the starting points of the project is that the rapprochement between art and science – that is visibly unfolding in the last hundred to fifty years[19] – is a lasting phenomenon of yet unknown portent. We have not quite yet grasped the full tectonic force of this movement, but we can map its progress from art to science – which is generally known – but also from science to art – which is rather mistrusted by scientists who are educated to the rift dividing the two disciplines. This is not the place to look into the reasons for said rift or to discuss CP Snow's *The Two Cultures*[20], but the rift is real, even if only as a cultural construct. It has personal consequences with a direct influence on research, whether artistic or scientific, as Michel Serres elegantly diagnosed in his *Passage du nord-ouest*[21]. Hyper-specialism for the one, a search for new tools and content for the other – the rift has equally an effect on the individual capacity of invention of scientists as well as of artists. The collaboration-confrontation with a different mind-set creates a new space of discovery, where these lacks and differences can be bridged, with – at least temporarily – a rift closing, a new space of discovery unfolding. Peter Weibel sees art and science coming together nearly as a wound that heals after five hundred years of separation[22]. The SciArt programme professes, more modestly, that what we need is a *democracy of disciplines*, a space of democracy between different methods of acquiring knowledge. We are convinced that this newly found respect could pave the way to more long-lasting collaborations and, to the benefit of all in the long term, a more permanent closure of the rift between science and art.

With all this in mind, the starting point of the SciArt programme is its DIY philosophy: it is more rewarding to put scientists in a room with artists and have them work on a shared project than to discuss cultural or philosophical underpinnings singularly with scientists. Even more, opening a space where artists can be inspired to conceive a new work based on science, injects into the process an invigorating dynamism that, in its turn, becomes a fertile breeding ground for discovery. Discovery of a host of potential forms of recombination, including commonalities of intent and similarities of method. At the end of nearly four years of the project, it is becoming clear that these discussions aimed at co-creation are mutually rewarding and beneficial for all participants. Where artists meet scientists the room fizzles with energy and wonder, bubbling with a spirit of discovery and enthusiasm.

As experimental programme, the SciArt programme has two particularities. The first is the diversity of science as practised within JRC. In the current edition, 12 disciplines are present, ranging from philosophy to bioinformatics, from quantum physics to earth systems science, from geology to data science. These still only represent a part of the different sciences practised within the JRC. In se, it is a rare privilege to be able to work with many scientists of these different disciplines, but it is important not to forget the corollary for the SciArt practitioners: that at the JRC, and thanks to its diversity, SciArt has been able to move decisively into new disciplines and fields. We consider that in this, the possibilities of recombination are limited only by the number and quality of the meetings between scientists, artists and policymakers.

The second particularity is the JRC's uniqueness in doing science in support to policy, which creates a strong attraction for both artists and art professionals. It is a measure of the generosity of artists - in a view on artistry that might be qualified as romantic – that they accept to commit to the role of antennae of the race; they are willing to take the risk to go further, to think along with researchers and policymakers to refine research questions and attract their attention to contemporary issues, in a programmatic respect for their artistic freedom. It is also a strong attraction to the artists to make art with and for policymakers and, by extension, the European citizen. The works displayed in the exhibition and throughout this book strongly manifest their enthusiasm for the European ideal.

Resonances

The figure of speech we chose to convey this active meeting of science and art was that of resonances, with a singular that refers to the physical phenomenon and a plural that is, strictly speaking, ungrammatical, yet opens up to pluralities of discovery and recombination. The metaphor of resonating bodies is a strong one – such as a string that starts to vibrate without being touched by a player or even more simply, the resonating body of a musical instrument. It indicates the project's intention to have science vibrate with art and art resonate with science, at once less and more than a full blending or a texture. It symbolises the respect for each discipline but indicates that in unique moments, they can find a common direction.

The flagship initiative of the SciArt programme is the Resonances festival, the result of a two-year cycle on a theme (or meta-theme) important to the European Commission. In the first year, artists are invited to the JRC site of Ispra to discuss their work with scientists and policymakers. The artists are invited to conceive, together with the scientists and policymakers, a new work based on science in support of policy. The ensuing art works are presented first at a festival in Ispra, bringing these innovative exercises to the place where research is done. Then the exhibition moves to an important art venue in Europe, to continue the dialogue with the European citizen. The Resonances II exhibition *Fair/Fear* was shown in the National Museum of Science and Technology Leonardo da Vinci in Milan in October 2017. For Resonances III, the exhibitions will be shown in the Bozar Lab on art and science, in Brussels Resonances III on Big Data/AI/Digital Transformation is presented in this book. The ideas and concepts behind the festival have grown since the previous edition. It has been possible to dedicate more time and space to the process itself than to a simple outcome, e.g. by establishing a programme for residences in support to the co-creation process of the festival. Attracting Freddy Paul Grunert, a professional curator with a long experience in SciArt, and Cristina Fiordimela, a professional exhibit designer with significant experience in science museum design, has certainly helped to gain depth and focus. Not in the least with the concept of *datami*, a neologism with a strong potential for capturing the many hot subjects swirling around Big Data, AI and Digital transformation. It focuses the variety of subjects into a strong image that helps to discuss some essential issues around the use of data, from fake news to privacy (see discussion below). Maybe because of this captivating image and certainly because of the subject, participation of JRC scientists has been enthusiastic and sustained, both during the initial brainstorming sessions on Big Data in early 2018 and during the Summer School in June of that year. Great dedication has also been witnessed with regard to the realisation of individual projects, both by scientists and artists throughout 2019. SciArt has worked its magic: works are still imputed to artists, but many of them have a true co-authorship, where the border between scientific input and artistic elaboration can become very fuzzy indeed.

Twenty-three installations were selected after the summer school and are presented in this book. The SciArt programme is proud to present one so-called satellite, a project sponsored by another institution interested to set up a collaboration on SciArt. The High-performance Computing Centre (HLRS) of Stuttgart[23] graciously allowed for computing time for the development of Renate Quehenberg's GAIA 5.0, a 3D hologram of Earth Systems Science data. This collaboration with a prestigious institute should be the harbinger of a network of research institutes participating to future editions of the Resonances Festival, in a growing commitment to bridge the distance between science, art and society and to disseminate the concepts of mature SciArt.

Datami | Curation

The concept of datami as title and quintessential concept for the Resonances III Festival has certainly helped to put at the centre of our reflections the personal life of each of us living through momentous change. So, what is a datami? Coined by Freddy Paul Grunert early in the Big Data brainstorm with JRC scientists in January 2018, the datami is an open concept that welcomes any interpretation and invites anybody to define their own version of it. A dense concept with many strands in art history and cultural studies, it is a contraction of the words data and tatami. It indicates a digital version of the Japanese mat, which is at once a ubiquitous piece of furniture used in a variety of situations, and a unit of measurement. As the smallest unit allowing for rest and meditation, it can thus function as a unit of personal identity; but it also invokes the active meditation of the Japanese Budo – resilience, personal strength, capacity to act.

Drawing on these images, the datami focuses on our new lives, balancing between a shifting reality and a *commercialised* one, and thus *objectified* digital life. Not online or off-line, as Luciano Floridi has remarked, but *onlife*[24]: a garbled hybrid where life seeps into the seams of claustrophobic digital containers where, under the pressure of merciless business logic, it is reduced to mere data points in massive databases. The Cambridge Analytica scandal has shown that some hundreds of data points can define a person better than a partner could – the ongoing digital transformation runs the risk of *hacking our minds*, as Yuval Harari puts it[25], reducing individual lives to a series of *hetero-directed* stimuli governed by potent but shadowy AIs in a computer thousands of kilometres away. Not Big Brother, certainly, but much worse and more effective than Aldous Huxley imagined in *Brave New World*.

Originally, the discussions on datami between the artists and the SciArt team centred on concepts like identity and its multiplicity, on the various strands of artistic,

Resonances III Datami
Exhibition and graphic design by Cristina Fiordimela,
Bozar Salle des Archives,
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Photo Nastassia Zenovich

scientific, religious and other forms of knowledge that constitute our shifting sense of self. The datami was presented by some, as a floating tatami with a budoka seated on it, who welcomes issues and sends them to scientific disciplines to be informed by facts, or to narrative enclosures to be enriched by fiction, or to artistic niches to be illuminated by art…, thus disclosing effectively the wealth and recombination of knowledge and culture on the internet. The datami therefore becomes a digital library, a personal *Kunstkammer* or a cabinet of curiosities. In this private digital space, personal history can be reconstituted with the help of digital trails and hyperlinks, and identity becomes the subject of experimentation in a hybrid environment, enriched by personal fact and digital association. The budoka could be seen as an avatar-in-cyberspace, a new and richer self, constituted of our digital trails multiplied by our libraries and encyclopaedias to the power of our values, in a space sheltered from the gabbling dataverse. In this manner, the datami becomes a place of rest and repose against the digital onslaught, as the initial curatorial statement put it, a place that restores our capacity to freely develop our expanding identities, but also a shelter and a refuge against the data deluge and digital transformation: *ataraxis in a digital whirlwind*.

In the Spring of 2018, the datami was a thrilling concept, with a unique capacity to envisage different worlds: a world of social media not constructed on psychological feedback mechanisms of gratification, and governed by the pressure of publicity; a dream of refounded social media as a tool of new encounters, an instrument of an invigorated democracy capable of reconquering its capacity for representation *onlife*, that is in a digital space reconciled with our offline identities; a dream of the *benevolent* and *creative* use of technologies, such as AI and blockchain to experiment with new virtual spaces in a refoundation of our democracies… Then came the Cambridge Analytica scandal. It was a collective awakening to what a young philosophy student has called the *tumefaction of personal life* under the pressure of social media and fake news[26]. More than a new space of freedom, it seemed rather that social media and our virtual lives ended as an ill-adapted and crumbling bridge between our on- and off-lives governed by confusion. Or as "echo chambers" of sometimes very legitimate malaise or discontent, whether merely shouted or openly fascist or racist. It might be true, as the Austrian political scientist Ulrike Guérot observes, that we live in a pre-revolutionary state[27], yet it is certain that the condition of malaise or discontent is then reinforced by our digital environments. For some datami artists, this enhanced the sense of urgency, but also the sense of fear towards a looming world of AI manipulation governed only by corporate profit. Less a proposal of possible alternative worlds with their promise of creativity and reinvention, and more a realisation of the urgent need to reclaim our data, in line with the calls of many institutions, organisations, companies and individuals.

So we wrote a *Manifesto* to coagulate all these thrusts towards a different way of treating our data. The datami remains, in the Manifesto, a space of multiple blossoming identities, but it does not shy away from evidence that cannot be eluded: *our data are ours*. It is a statement that can be read as too radical or too naïve, but it is most certainly in line with the philosophy of the GDPR. It is also in line with will.i.am's concept of personal data as a human right and the Magna Carta of the Web as found on the website of the British Library[28] and warmly supported by Tim Berners-Lee. Berners-Lee observes that "… [O]ur rights are being infringed more and more on every side, and the danger is that we get used to it." At the same time, his Solid protocol seems the most concrete proposal to democratically resolve the issue of our personal data. The Manifesto clearly states that this must be resolved – it calls for a *digital declaration of independence*, or a need to redefine and so reclaim our personal freedom. In other words, we think that this can only be resolved by a wide, open and democratic discussion, with as many people as possible. It is essential that we put forward our unalienable right to privacy, and that the use of our data by companies be called what it is: a seeming theft of personality. This is what the Resonances III participants urge the European citizen, and, by extension, the JRC and the European Commission to do: to take a role in a renewed affirmation of our unalienable rights and European values.

The works in the Datami exhibition do not necessarily have this sense of political urgency, but they all invite to reflect on the effects of Big Data/AI/Digital Transformation on our personal lives. They are the result of various collisions between artist and scientist(s) on the background of their personal datamis. The artists have warmly embraced the concepts developed by the curatorial team, each declining it according to own practice and encounters. In their works, the datami can be as personal as using your own DNA or simply be simmering in the background. The concepts behind it can be a thread in their work on AI or simply become the starting point for a discussion on time. All of them, though, embraced the concept and set to work with it as they felt it, in total freedom. The resulting works are not an exercise of style or a set of variations on a single theme, but a free artistic elaboration of the dialogues on datami, data and personal freedom within the context of JRC science. In line with the SciArt Strategy, we have favoured not a technique or a discipline, but a voice that was capable of declining the urgency of the moment or of exploring the personal effects on our private lives. The result is an intriguing exhibition with a wealth of different interpretations of the datami concept intertwined with emergent science.

Like Resonances II, this exhibition shows that integrating art into the life of a research institute can bring unexpected and fascinating results. Both artists and scientists expand their knowledge and work with novel concepts, as most of them do in the works issued from the collaboration. It can help scientists to have a new look at their subject, rediscovering it with the eyes of the other. It is a process of opening and enhancement, subjective and objective, free and entangled, always capable of linking disciplines and domains. We think that for all, it certainly created tension and expectation – or freedom and more simply, *fun*.

It is most of all an invitation to all, citizens in the first place but also institutions, organisations, NGOs, and all stakeholders, including the European Commission itself, to collectively discuss our fragile European datami, in all its complexity, with its benefits and drawbacks. It is a necessary exercise in democracy, which we all know needs to be reinvigorated.

As the Manifesto says:

> *In short, it is democracy. Let's do it together.*

That is what this exhibition aims to achieve.

Notes

1. By 2006, the world had accumulated 180 exabytes, compared to 12 exabytes accumulated by all humanity before the advent of the computer. The number was 33 zettabytes in 2018 and is expected to grow to 175 zettabytes in 2025, see L. Floridi, *The Fourth Revolution,* Oxford OUP, 2014, p. 8 e.v. & "Global DataSphere to Hit 175 Zettabytes by 2025", IDC Says, in: *Datanami,* November 27, 2018, at https://www.datanami.com/2018/11/27/global-datasphere-to-hit-175-zettabytes-by-2025-idc-says/.
2. 1 exabyte is 1000 petabytes or 1,000,000 terabytes. 1 zettabyte is 1000 exabytes.
3. Nick Bostrom, *Superintelligence, Paths, Dangers, Strategies,* Oxford OUP, 2014.
4. Cathy O'Neil, *Weapons of Math Destruction,* New York, Crown Books, 2016.
5. The Economist, 6 May 2017.
6. Regulation [EU] 2016/679 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC [Data Protection Directive], L119, 4 May 2016, p. 1-88.
7. See e.g. https://medium.com/mydata/five-loopholes-in-the-gdpr-367443c4248b on five loopholes for companies not wanting to comply. For the kind of wording used in these preparatory articles, please see https://wp.nyu.edu/compliance_enforcement/2017/12/11/the-general-data-protection-regulation-a-primer-for-u-s-based-organizations-that-handle-eu-personal-data/
8. See e.g. New York Times, April 10, 2018, Mark Zuckerberg Testimony: *Senators Question Facebook's Commitment to Privacy* at https://www.nytimes.com/2018/04/10/us/politics/mark-zuckerberg-testimony.html.
9. See e.g. BBC news, *Zuckerberg's European Parliament testimony criticised,* at https://www.bbc.com/news/technology-44210800.
10. The Economist, 21 January 2019, will.i.am, *We need to own our data as a human right—and be compensated for it,* p.14
11. See https://solid.mit.edu/.
12. See https://www.bl.uk/my-digital-rights/magna-carta-2015
13. C. Wood, S. Livingston and M. Uchida, eds, *AI more than Human,* London, Corporation London, 2019.
14. McCarthy, John *What is AI* at Stanford University website, http://jmc.stanford.edu/artificial-intelligence/what-is-ai/index.html
15. S. Lloyd, "Wrong, but more Relevant than Ever", in: J. Brockman, ed, *Possible Minds, Twenty-Five Ways of Looking at AI,* Penguin Press, New York, USA, 2019, p. 7-8.
16. Term used by Yuval Harari in *21 Lessons for the 21st Century,* London, Vintage Books, 2018.
17. The first metaphor is Ezra Pounds, from *ABC of Reading,* New York, New Directions, 1934. The second is an American saying often ascribed to Marshall McLuhan.
18. Michael John Gorman, *The third Culture,* [review of Arthur I. Miller's Colliding Worlds], in: *Nature,* vol. 510, 11 June 2014, p. 216. The full sentence reads: "The important question that remains is whether such art can alter the direction of scientific research, beyond provoking public discussion and debate." Gorman was at that time founding director of the Science Gallery Dublin.
19. See for this, to name but two: Arthur I. Miller, *Colliding Worlds,* New York and London, W.W. Norton & Company 2014 or Siân Ede, *Art and Science,* London and New York, I.B. Tauris 2005.
20. C.P. Snow, *The Two Cultures and the Scientific Revolution and The Two Cultures and a Second Look* , Cambridge, Cambirdge University Press 1959 & 1964.
21. Michel Serres, *Hermes V - Le passage du nord-ouest,* Paris, Les Editions de Minuit 1980, p. 17. Serres eloquently speaks of *instruits incultes* [uncultivated men of learning] and *cultivés ignorants* [cultivated ignoramuses] nailing down, in a few sentences, the effects of the rift between natural and humanistic sciences [or science and art].
22. P. Weibel, "Molecular Aesthetics, An Introduction", in: Peter Weibel & Ljiljana Fruk eds., *Molecular Aesthetics,* ZKM & MIT Press, Karlsruhe – Cambridge, 2013, p. 37-78.
23. See htts://www.hlrs.de/home/.
24. Luciano Floridi, ed., *The Onlife Manifesto,* Springer, 2012
25. Yuval Harari, *21 Lessons for the 21st Century,* London, Vintage Books 2018.
26. In various conversations in the streets of Bologna.
27. Ulrike Guérot, *Why Europe Should Become a Republic!,* A Political Utopia, Bonn, Dietz Verlag 2019, p. 48.27
28. See https://www.bl.uk/my-digital-rights/magna-carta-2015.

If Wetware Takes Command…

Freddy Paul Grunert, SciArt Curator

If the self is a wetware
and the self is aware
It becomes a ware

If wetware – self-awarely becoming self a ware – takes command; if, by consequence, the human spirit binarised by wet softwware would be expelled from the humanities; and categories like mind, human and history would shift fundamentally; if it would be put under the control of algorithms – functions of discourse network and their media: the second curatorial statement on Datami could be at risk and mother's mouth (Kittler) would be gagged forever.

I.

Mother's mouth cannot be gagged forever[1]. Nowadays data inflation in reading and writing, in breath and research could play *subvocally* on historical forces, allowing for the emergence of a new agency: SciArt. SciArt can address one of the persisting lacks in modern science – the lack of a "mood" in science as well as in art, which influences our collective views on world, nature, matter, relations – in one word, reality. We would say it may be similar to the "implicate order" of David Bohm, dominant factors determining relationships of dependence and interdependence of different elements. We call it mood in an attempt to describe a spectrum of colours, emotion, attitudes such as readiness for action or desire for understanding, a general *standing-in-the-world* that indeed colours the way we look at the world. It is, in other words, more than filters as we know them from technology, but refers to the momentary complex of knowledge, emotion and desire with which we interpret the world – a correlation between the known and the unknown. The mood is the centre of our being, the intersection of the collections composing a set, where the collections are the different circles of our awareness – science, art, relationships, the whole of our interests that determine our life and actions.

Nowadays, mood is not recognised as a prime generator or the cultural machine of the many agencies that compose society; awareness of its influence is repressed or relegated into a sphere of intimacy, while in reality it also shapes society's collective feelings and outputs. As a result, the prevailing mood of society is relegated to corporate euphoria in a merciless mercantile logic – a logic of wares – that use various fads to hook up undeclared aims and hidden orders. The clamour surrounding Big Data, AI and digital transformations is only the latest fashion that must help to uniformise human desire, in a system that in the end seems bound to establish social credits already implemented in some Asian societies. The antidote to this artificial and falsifying mood of euphoria seems a certain melancholy – but not melancholy in the sense of Lars von Trier's film or Albrecht Dürer's interpretation of the ruling image system. While crossing Europe's cultural landscape from the North to the South, where melancholy was a subset of isolation, Dürer transformed the concept as resulting not from isolation, but from separation, which allowed for distance that in turn allowed a conversion of a personal intimate mood into knowledge – what we would now call a data set. Rather it is melancholy as a philosophical mood, a psycho-logical attitude, logical with incorporation of emotional intelligence, where the latter also yields the former. The contrast between logical and *psycho-logical* comes from the pages where African philosophy makes an effort to emancipate itself from the occidental cultural system, with the emergence of a consolation philosophy like that of Ada Agada, in an attempt to take into account the religious, scientific and philosophical perspectives typical to African society and history[2]. For Agada, being in the world is not sufficient unto itself because it is that being who must appeal to something greater than, and external to itself, to fully realise its joy. In his book *Reinventing Ontology*, his doctrine of mood sees humans of all races converge in the melancholy being for whom there is no meaning to human existence beyond the spheres of joy and sadness, especially today in a life fraught with existential challenges. He condenses African episteme to constitute the answers to two fundamental questions: is the universe pointless? And is human life futile? Agada sees mood as a primary form of intelligence, the basis of feeling, a proto-mind from which advanced reason arises[3].

Situated (that is, experienced or embodied) knowledge implies that social, cultural and historical factors will constrain the process of knowledge construction. It is not only about knowledge, but about how this knowledge is situated within personal life, integrated into the full personality of the knower. That is where SciArt, at the intersection of various forms of knowledge, functioning like collections of set theory, draws its force. We see it as embedded knowledge affected by history and personal history, localisation in society, and thus by language and values, the coming together of meaning and matter in the inevitably culture-bound nature of all viewpoints.

Dear Freddy,

It is not easy to device a good title. The great Italian newspapers know it, and fight to get the best “titlists.”
“Datami” is a genial title. In its clever word play, it contains deep meaning. It tells us that Big Data dates us, meaning they identify us and create personal and social identities. In “dating” us, this title also suggests that a database is a historic collection, an archive. It is also the cartographic representation of our present. Today, databases are our public library and our private archive, the way in which History and the stories of the Self are mapped and narrated. “Datami” invites us to explore how we can critically resist or reinvent these strategies, and even rest from overwhelming data flow.

Giuliana Bruno, 12 March 2019

Emmet Blakeney Gleason Professor
of Visual and Environmental Studies
at Harvard University

Resonances III Datami
Visual Identity
Coordination by Angela Cardinali
Graphic design by Cristina Fiordimela
Depliant
Summer School, JRC Ispra site
25-29 June 2018
Photo Cristina Fiordimela

Looking at European sources, we find in ancient Greece the term *metanoia*, usually translated as changing one's mind, and implying the transformation that comes with a conversion, including connotations of regret and repentance – that is, the combination of more than one viewpoint, at least a before and an after, within a context of personal turmoil. We could associate this with the mathematical term *nearest neighbour*, a relational connection of spatial points in a non-existing space, separated in space-time but entangled, the substratum of the real fully integrated into the real: all the conditions that created a situation, again, with the inclusion of a personal state of mind or mood, where desire and knowledge are intertwined in a vital and productive alliance. Combining this with SciArt as intersection in set theory, SciArt becomes the faculty that allows a condensation of local reality, capable of combining various viewpoints, the border at the plane of knowledge. We think, in other words, that in this conception, SciArt can give an answer to what is commonly thought of as the reason for the crisis in modern science: the questions of *representability*, of *locality*, and of *representation*. Again, in order to solve these questions, we need a *localised* knowledge capable of *conversion* that establishes a new and productive separation, renewing the representation in an embedded practice. To stay in Greek thought, it becomes thus the opposite of hubris, "the arrogance inherent in a (single) point of view".

It is this embedded form of knowing that opens up to what Robert Laughlin et al. called the *Middle Way*[4]. Looking for as-yet-undiscovered principles that might be at work in what they call the *mesoscopic scale*, which is intermediate between atomic and macroscopic dimensions, and the implications of this middle way on biology and physical sciences, Laughlin et al. state: "The search for the existence and universality of such rules, the proof or disproof of organising principles appropriate to the mesoscopic domain, is called the middle way." The missing clue is to bring together evolution, emergence and non-linearity. Laughlin et al. do this by looking at the level of large proteins in biology, still very incompletely understood, but acting like computers executing a series of instructions favouring life. Mesoscopic behaviour can also be found in non-biological systems, such as glasses, exhibiting a wide range of time scales of motion, including indications that entire mesoscopic regions reconfigure themselves cooperatively. Investigating this *middle way*, is for the authors a central question of modern science – pointing to our inability to *see* this dimension between the very small and the very large.

For us, SciArt is mesoscopic. It is the middle way that opens to embodied knowledge, creating an abstract space of *disruptive innovation* and complex systems. That means the emergence of a coming out of a cupboard of prejudices, encompassing the binary drive of intentional and non-intentional meaning. In other words, it is the resolution of binary 0 – yes/1 – no systems and abstract probability sets with a reinvigorated capacity to combine more than two elements in polyhedral thought. Taking into consideration that objectivism is a philosophical idea, not logically following from what science tells us about the physical world, or from the scientific method itself. This implicates philosophical bias in the analysis of reality, not a mere data point, while scientific materialists ignore the ways that immediate experience and the world can never be separated from the statement of scientific fact – in final analysis, from nature. This is where the mood of SciArt can embrace the life-world of human experience as the grounding soil of science, and thus from the existential and spiritual crisis of modern scientific culture: what many call the blind spot.

The blind spot arises when we believe that the scientific method gives us access to naked reality. There is no way to render reality apart from experience: we must wake up from illusions of absolute knowledge suggested by philosophy, as if our ways of measuring nature would be a source of nature's self-understanding. Referring to Whitehead and the bifurcation, reality is made up of evolving processes that are in equal measure physical and experiential.

II.

Curating the Resonances III Datami *process* must be seen in the light of the preceding. The JRC is a space of intersection of sets of disciplines: sets of various sciences and different policies, but also sets of relationships, power, policy and societal freedoms, landscape, architecture, laboratories, and history. These sets all carry a degree of freedom, which Resonances III interprets like an agora intended in the original sense of the word, a crossing of public space, a topology of human relations and their embedded knowledge, coupled to the need to express desires. In this complex reality of day-to-day practice of a service-minded science (in support of policy), SciArt becomes *mother's mouth*, the set that intersects with all sets incarnating their particular agency. SciArt opens up to the middle way, fully retaining its own agency of degree of freedom to recombine this complexity in an embodied practice.

For a curator interested in these intersections, the JRC presents itself as propitious terrain of experiments, or, in an easy metaphor, a laboratory of SciArt agency. The motivations are clear, as are the institutional resistances to the intrusion of an 'other' that is not part of the expectations of researchers. The question then becomes how to create a space where SciArt can deploy its degrees of freedom and establish its middle way as a welcoming space of experiment. The JRC is

Datami,
Cristina Fiordimela, Datami Icon
Freddy Paul Grunert, Datami Concept Intellectual Property
February 2019

perfect in that it does not confuse the boundaries between art and science, to the opposite of certain research in this field in the past. The separation and conversion we are looking for are similar to Mary Catherine Batesons' new approach to knowledge. Quoted by Catherine A. Jones in her "cybernetic epistemology": the individual mind is immanent, not only in the body, but also in a larger Mind, of which the individual mind is only a subsystem in concert with other entities – webs of symbiotic relationships that form patterns we need urgently to sense and harmonise with[5]. Here, we are aware that biologists and anthropologists are otherwise engaged with trans-species understanding of intelligent systems, and keep in mind Gregory Bateson's observation that corporations merely simulate "aggregates of parts of persons" with profit-maximising decisions and are cut off from "wider and wiser parts of the mind"[6].

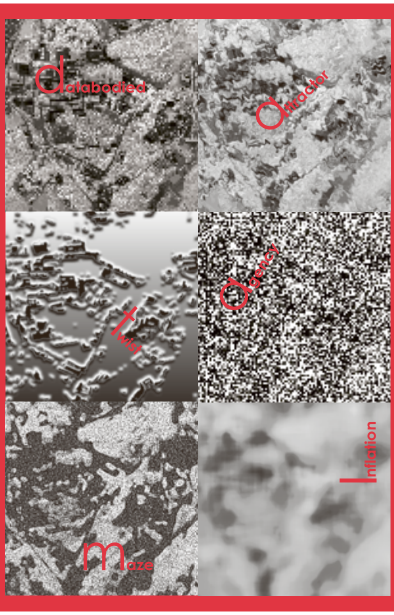
The *Datami*, as a device of SciArt, is a situated research of proxemics, i.e. the study of distances. It allows for a much-needed separation, not only of daily practice, but also of a life-long endeavour as researcher, whether scientific or artistic: it is not the ambition to make world-shaking discoveries or solve universal equations, but to shine a light upon the crack that the coding of Artificial Intelligence-machine learning forces upon the social contract and the very scaffolding of civilisation. Quoting a recently published EU-funded research[7], on the one hand, the agency of individuals and groups is starting to approach that of nation states, while on the other, our mobility and hard-won rights are under threat. What tools do we need to understand this new world of AI and machine learning, where technologies increase powers of surveillance, allow corporations to extract ever more complex working arrangements, and how can art assist in envisioning and enacting other possible futures? We try to break the "innocent technosphere" established by male IT scientists and cybernetic artists from the 1950's on, of which the art of the 1980's showed the apocalyptic limits in films like *Bladerunner*, and which, in the 1990's, became the object of feminist artists' criticism. The latter tackled the question of whose intelligence AI was attempting to simulate as a completely suffusive condition that demanded our critical attention. For an artist like Lynn Hershman Leeson, responding to the technical triumph of cloning Dolly the sheep, it was crucial to draw the connection between meat production and meat machines.

Curating SciArt means, in other words, reflecting on algorithms or rather, reading algorithms with a profound understanding of their level of abstraction and of the process that, when entering the field of a unstructured reality, embodies an idealised space of digital processing, which on its turn is implemented in complex aggregates of abstraction, simulation and concrete lives. This is related to Norbert Wiener's warning of 1964. Disenchanted with the "gadget worshippers", Wiener stated that the danger did not lay in machines becoming more human-like, but in humans being treated like machines, having observed already in 1959 that "… The world of the future will be an ever more demanding struggle against the limitations of our intelligence, not a comfortable hammock in which we can lie down to be waited upon by our robot slaves ". His warnings went unheeded for fifty years because, as Judea Pearl, specialist in Bayesian networks observed, Wiener was not enough of an IT specialist and did not use the fashionable metaphors such as *programming*, *codes*, *computational functions*, *short- and long-term memory*. In one word, he spoke analogue.

Discussing the theme of Big Data, AI and Digital Transformation with SciArt stakeholders at the beginning of the process, a recurring objection was that we came too late, and that by the time of showing, the exhibition would already be obsolete. In short, we can quote Ray Kurzweil's *The Singularity is near and superintelligence is already here*, to observe that the contrary has happened: not only is current machine learning a far cry from superintelligence, but Big Data and AI are still prominently present in the public mind, with the cry for a different world slowly gathering steam. The awareness has only become greater, that current machine learning operates almost exclusively with statistical inference in a blind-curve *fitting mode* model, lacking sensory input from the environment.

The Resonances III Datami installations investigate the gap between the *abstract desire* of the algorithm for answers, as written by a scientist, and the real-time implementation of this kind of processing. They shine a light on the complex series of intersections between the moment any data enters the black box and the result coming out of it. The artists are hereby able to capture the mood of the writer at the moment of writing the algorithm, making it together with the scientist into the middle way. We want to therefore stress the importance, not so much of the results, which are intriguing for their part, but of the process that scientists, policymakers and artists have followed. The novelty for curation is to establish and enhance this common space, this intersection or this series of intersections where the spirit of experiment can profit from the freedom that we see as inherent in the SciArt process.

It is also in this sense of shared processes that we introduced the concept of *opera*. Taken from Italian, as antagonistic to the term artwork, it indicates in this radical change of lexicon the need to leave behind the classical concepts of the aesthetic, and rather consider the art world as the "art-machine spinning freely" that the Italian philosopher Giorgio Agamben describes in his *Creazione*



d a
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JRC RESONANCES III FESTIVAL AND EXHIBITION

sciart society

European Commission

BOZAR

Resonances III DATAMI

Ceçi n'est pas une post-card

but you can use it
for the bund date
on the Datami exbiton
in Ispra or in Brussels.

Believe it
or Not!

d a t a m i

RESONANCES III Festival JRC Ispra 14 - 18 October 2019
Exhibition JRC Ispra 14 October - 8 November 2019
Exhibition Bozar Brussels 10 December 2019 - 20 January 2020

TIME PROCESS TIME EVENT TIME KILLING TIME TUNING TIME CONSERVED TIME INFINITE TIME BUOYANCY TIME

Sciart Resonances III Datami
squints at and beyond the Blind Spot
Avoid mass delusion look for the real,
reality, where science is boxed in
standards,
QBits, Split Strings,
Susy's missing Planck Dimension,
batting eyelashes to a new Collider
Great Wall.

The Sciart Resonances III
Datami Festival
Relational Spaces
will inflate digital transformation,
emerging agencies galore
our experienced immediate living
exploring flaming conundrums of
nature
truth geometry beauty measurement
matter
ruling out bifurcations that blur our
embodied immersion in the real.

Resonances III Datami
Visual Identity
Coordination by Angela Cardinali
Graphic design by Cristina Fiordimela
Postcard and excerpt from Booklet Datami
with text by Freddy Paul Grunert
Exhibition Milano Digital Week
Palazzo Giureconsulti, Milano
13-17 March 2019

Resonances III Datami
Visual Identity
Coordination by Angela Cardinali
Graphic design by Cristina Fiordimela
Posters and postcard
Exhibition BozarLab, Brussels
10 December 2019 - 9 January 2020
Photos Riccardo Pareggiani

e anarchia[8]. Agamben starts from Robert Klein's *eclipse of the artwork*[9], which defines the elimination of the work as a major target of avant-gardes, passes to Guy Debord and his situationist declaration that they wanted to at the same time abolish and realise the work of art to discuss the changing status of the concept of artwork since ancient Greece. He comes to the conclusion that the concept of artwork is empty, while contemporary culture creates a host of works not any-more bearer of Aristotle's original *energeia* (creative force) contained within an *ergon* (work). Rather, we recognise that any work of culture that we consume is the result of more or less extensive collaboration between different skills, travel-ling in impromptu collaborations on ever more cluttered digital highways. In this way, the term opera indicates this open, collaborative space where scientists and artists can meet without the burden of cultural heritage or the spinning of an art-machine running wild.

From SciArt as a middle way, an intersection of the JRC's many intersections, from process to opera, from science to art, this catalogue intends not to illustrate or reproduce the artworks but to document the process in Ispra. It does so by trying to capture the individual voices and personal histories, in order to docu-ment this middle way between science, art and policymaking. By expanding the catalogue on the internet, it becomes a re-visiting tool that even if one has not seen the exhibition in the JRC and more, not witnessed the energy fizzling in the room during the 2018 Summer School, or visited the labs in Ispra, it is still possible to capture a glimpse of the uniqueness of the Resonances process in Ispra. It is a testimony to the courageous decision to open an institutional research institute with the decision to support policy that influences the lives of all European citizens. It is also the result of a curatorial decision, to put the process at the JRC squarely at the centre of our work, showing science at the JRC, and exalting the arts at a vital intersection of our knowledge.

Transferring the exhibition to the Bozar in Brussels, without eclipsing the intelligibility of this intersection, we are aware that we will be finding a different force field. We hope that this can lead to an augmented set of interactions, where SciArt – the intersection of art and science – can give rise to a new intersection with society. The exhibition design exalts this intersection of science and art in the JRC, and brings it to Bozar to bear fruit.

Imagination of Things,
Disjointed Research Machine
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 – 19 January 2020
Installation view
Photo Imagination of Things Archive


Reverberations
Eigenstate
Shape shifting
databodied
Oblivion
agency
Negentropy
twist
Ad hoc assumptions
attractor
Nearest neighbour
maze
Contingency
inflation
Erasure
Solicitation

Resonances III Datami
Visual Identity
Keywords and Poster for the public
Graphic design by Cristina Fiordimela
Text by Freddy Paul Grunert and
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Installation views
Photos Riccardo Pareggiani

III. Epilogue

We think it is important to dwell on the mood of the process. The conversations with the scientists, the technicians, the administrators, the visitors, the artists but also with the landscape, the plants, the witnesses of past research on the Datami itinerary in the Joint Research Centre's landscape with the breath of the Lago Maggiore, has created a persistent mood of melancholy as a form of metanoia, a conversion where different point of views are held together in a fragile equilibrium, giving alpine-coloured contours to our weak society.

1. For the concept of Mother's mouth, see Kittler, Friedrich A., *Discourse Networks 1800/1900,* Translated by Michael Metteer with Chris Cullens, Stanford, Stanford University Press, CA, 1985, p. 25-69.
2. Agada, Ada, *Existence and Consolation: Reinventing Ontology, Gnosis, and Values in African Philosophy,* Saint Paul, MN, Paragon House, 2015.
3. Agada, Ada, "A truly African philosophy", in: *Aeon* at https://aeon.co/essays/consolation-philosophy-and-the-struggle-of-reason-in-africa.
4. Laughlin, R. B., David Pines, Joerg Schmalian, Branko P. Stojkovic, and Peter Wolynes, "The middle way", in: *PNAS,* January 4, 2000, vol. 97 no. 1, p. 32-37.
5. Jones, Catherine A. "The Artistic Use of Cybernetic Beings" in Possible minds: twenty-five ways of looking at AI, edited by John Brockman. New York: Penguin Press, 2019.
6. Bateson, Gregory, *Steps to an Ecology of Mind*. Foreword by Mary Catherine Bateson. Chicago and London: The University of Chicago Press, 1999 [1972].
7. Quoting a recently published EU-funded research [https://networkcultures.org/blog/publication/state-machines-reflections-and-actions-at-the-edge-of-digital-citizenship-finance-and-art/], on the one hand, the agency of individuals and groups is starting to approach that of nation states
8. Agamben, Giorgio, *Creazione e anarchia, L'opera nell'età della religione capitalista,* Neri Pozza editore, Vicenza, 2017.
9. Klein, Robert, *"L'éclipse de l'oeuvre d'art",* in Vie des arts 47, 40-50.

Kaleidoscope of images of Datami artists,
and *Making of the Datami festival in JRC Ispra site*
by Amal Mokded
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 – 19 January 2020
Installation views
Photo Riccardo Pareggiani

Scientific coordination of the SciArt project. A Brief.

Francesco Mugnai, *Scientific Coordinator of the SciArt project.*

In this historical period, it seems that the major part of institutions, private companies and individuals is tending towards a race to the most evolved, to the next threshold of invention, towards an ever more unremitting technological evolution, towards ever new findings in scientific research. A distracted observer could get the impression of a quickly growing stain, or an infection that spreads everywhere in a few years – that is, very rapidly, even for a mature society. The infection spreads from the most remote confines of the digital universe – including but certainly not limited to Big Data and Artificial Intelligence (AI) – up to the most *mediatizzato* innovations in the field of biology or ecology, medicine or engineering, economics or finance, up to the field of governance, not to mention the explosions of apps that promise to improve our lives. This change, driven forward by a strong hybridisation of disciplines and roles, seems quite universal. As researchers of the JRC working on the borders between science and policy, we are inevitably swept away by this movement. The strong propulsion towards innovation in all fields gives us the impression to be up against a real innovation epidemy or more, a real pandemic of novelty where reality seems to be topsy-turvy: it is indeed not difficult to imagine that the sickness is, in this case, the real motor of innovation, and not the cause to eradicate, which then provokes comments on anthropological mutations, even of our democracies. In many fields, we see key players that seem to have mastered a new method, with marked skills in transdisciplinary recombination, reinforcing the idea that the "infected" evolve quicker, accelerating the acquisition of superior pioneering skills.

In such a climate, mutations occur more frequently, and in far superior numbers. It is here that institutions like the European Commission are called upon to play their role, providing a cure while often suffering from the same ill. They have to go in higher gear to keep up with the times, to maintain the solidity of their scientific research in a changing context. The old methods of sharing their findings with society do not work as before while they still are bound in exercises of horizon scanning to be prepared for the next novelty.

The SciArt project plays out in this context and is strongly geared towards its objective to investigate and aliment creative processes, in scientific and artistic research. The JRC hosts a multitude of scientific disciplines to push forward its institutional mission of science in support of policy. This multidisciplinarity allows it to benefit from hybridisations in a massive way. The SciArt process itself is not bound by a single vision but is composed of various interpretations that reinforce each other through complementary actions – as mentioned elsewhere in this book, the possibilities seem only to be limited by the quality of the encounters and the space (also the institutional space, in time and resources) that are needed for the elaboration of projects.

The research processes of SciArt evolve in an epistemological multiverse and take form through bold collaborations on the frontiers of and between disciplines. The project allows not only for a deep blending of various scientific disciplines, but it also promotes close and honest dialogues between different artistic and scientific disciplines. JRC activities are concentrated in units, departments, each of which is in charge of specific themes such as Cybersecurity, Crisis Management, Health and Food and many others. The units that have collaborated with the project are more than 30 on a total of 70+; even the more technical, logistical and administrative units have been involved. The result is visible in the Resonances Festival, where each art installation is the result of efficacious hybridisations – as if the virus of transdisciplinarity were rampant – and issues and catalysts mingle and blend, reacting as in a primordial soup. One of the reasons of the success, the growing participation of JRC scientists, can be found in the fact that the encounters between scientists and artists liberate an inebriating energy, a return to an enthusing tabula rasa that effectively opens up new research vistas for both disciplines.

Yet, in the extended community of researchers, administrators, technicians and policymakers that make up the variegated body of the JRC, not all share the same concepts on the SciArt project. There are different ways of responding to the project.

Some see in the integration of science with art an exorable process, one of the few ways to achieve a really effective development capable of capturing the explosive historical moment we are living through. Some others see this integration as more problematic, needed mostly to satisfy the desire for novel methodologies where rather than developing new ones, rather a passing fad than a direction towards substantial progress in research.

Still others are curious without inclination to really take part in the process. They might make allowances that these epistemological collisions might result in lasting results. Often, they have a pronounced interest in art or are amateurs practising art themselves. Yet again, art remains an unknown to them, at least in its contemporary and professional form, which does not diminish at all the authentic open-mindedness towards pursuing new dialogues with other disciplines.

Finally, there is no dearth of doubters and sceptics, up to a small minority ready to sabotage the process. We consider them as still living in what is, in the end, the cultural construct of the two cultures, with a strict separation between science and art. Sometimes because of narrow-mindedness, sometimes because of ideology (in the sense of the impassable rift between art and science), but often because of a fear to be contaminated fatally, they keep aloof of the project and refuse to cooperate at any level.

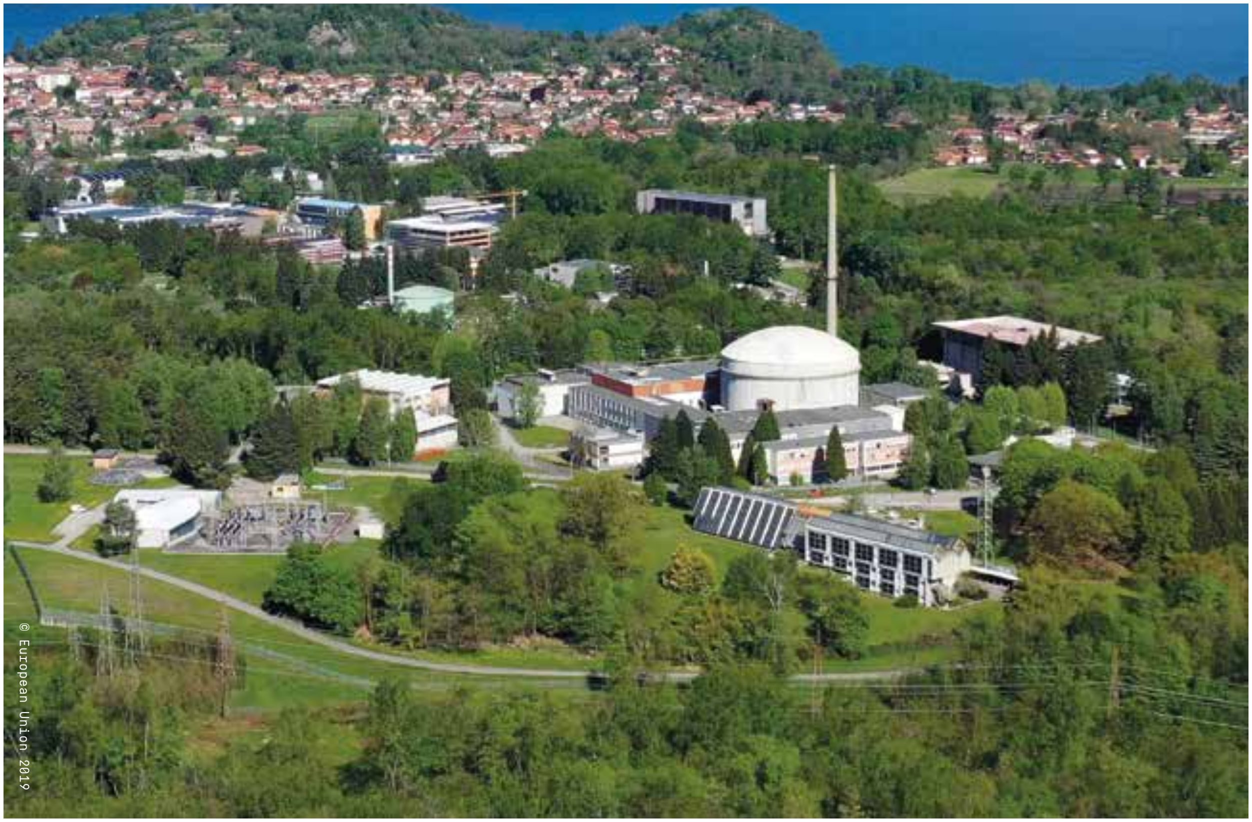
Since 2015, all these different attitudes have had the occasion to express themselves and more, they all have interacted in one way or another with the project. The most surprising results were obtained where all different attitudes have been dragged into collaboration, e.g. when a convinced backer may have involved a sceptical whose scientific knowledge or technical skills were paramount to finalise an art installation. In the end, in these four years, more than 100 artists and as many scientists have met, collided, and found common ground. They have participated as functional catalysts to this process of blending scientific and artistic research and collaborated with the artists in works if not of real co-creation, at least of active co-production of commonly conceived proposals. The most enthusiastic and convinced scientists have shown, time after time, their mettle in devising workable solutions to realise these artworks, of which more than fifty have been created in the three editions of Resonances.

Before, we mentioned that institutions too have been infected by the strong transdisciplinary and experimental push typical of the SciArt process. Practising SciArt as a researcher, and even more as scientific coordinator of the project, requires a great deal of self-study. One needs to master instruments and techniques that are typical for other disciplines (whether scientific or artistic), embracing a form of continuous learning of the *other's* skills that is sometimes harsh on one's own skills and competences, which were often acquired with much effort. Yet the willingness and capacity to enter into other fields is a useful skill when confronted with diverse themes (such as Big Data) and changing groups of participants – it is also a boost for communication skills to consciously work on pushing borders, opening, for each edition, to other disciplines and cultures, interests and attitudes. This also applies to organisations: learning to employ external competences not part of the organisation's classical competences, in an open dialogue with a different *culture*, is enriching for the organisation too and can be seen as an essential element of an innovation toolbox.

I have often been tempted to see the SciArt project also as a social experiment – in line with the project's subtitle invoking science, art *and* society. This part of the experiment consists in understanding how a specific scientific community, that of the JRC, responds to such a momentous challenge, that engages all hierarchical and functional levels vertically as well as horizontally.

It would undoubtedly be interesting if not urgent, to capture the evolving responses of single scientists, of the different groups with different degrees of acceptance, and of the entire community. It might be done with a questionnaire capable of mapping the changes in attitude and degrees of conviction towards the SciArt process. A most eloquent indicator are the figures of growing collaboration between scientists and artists. From four at the first edition of the Festival, it went to some twenty in the second one, arriving at 49 and, in the period of residences, more than 80 in the third edition of the two-year cycle 2018-2019. A similar remark can be made about the artistic quality of the realised artworks, intended as their capacity of receiving recognition from the international art world. At the same time, the 2019 residences programme has allowed for deeper collaborations, often with a great programmatic felicity on a scientific, artistic and personal level, giving a strong push to the experimental character of the project. Indeed, in the conceptual phase the projects pushes for open proposals, with a strong experimental component on artistic as well on scientific level.

A similar clear trend of growth can be found from the viewpoint of scientific production, even if it is less consolidated. In the beginning, scientific contributions were limited to a rehash of pre-existing research texts used for internal publication. In the second edition, it included participation to international conferences with peer-reviewed publications touching upon new research themes. The production of the third one can only be verified in the aftermath of the Festival and Exhibition, but it will be an important indicator for the future development of the project in the coming years.



Joint Research Centre
Ispra site
Photo JRC Archive

Art and HPC – When the Result is Morethan the Sum of its Parts

Andreas Wierse, *Director SICOS BW, Stuttgart*

At first sight, the three lettered word art and the three-lettered acronym HPC (High Performance Computing) do not appear much related. They rather seem to be at the opposing ends of a scale that reaches from (cold) technology to (warm/ human) creativity and emotion.

However, for us at the "High Performance Computing Centre Stuttgart" (HLRS), this is actually a motivation to look closer at how these two topics could be explored together, and how they could benefit from one another.

For us, this is not as difficult as it might appear: the computers that we provide are basically tools for our users. Their goal is not to just use the computer (in fact never ever we had someone approach us: "I would like to user your computer!", "What for?", "I don't care"), but they usually want to solve a problem. In the essence, our computer is a tool for them. Therefore, it is not absurd to assume that our fast computer could be a tool for an artist, an enabler.

From the other perspective, that of an artist, it is actually not so different. Many artists use tools, ranging from a simple pen to really complicated electronics; so, they might also be open to use our powerful tool. Now, the problem has been that our computing centre staff rarely has contact with artists; and the artists usually do not know, what the capabilities of a supercomputer would allow them to do.

In order to fill that gap, it is necessary to communicate with regard to the existence of the computer as well as of the artist. However, it is not sufficient to simply know about the existence of the other, it is also crucial that they understand each other. Knowing about the existence is simply adding up the two components, while understanding opens up new dimensions, actually multiplying it (figures larger than one of course;-). The result will be more than the sum of its parts!

Our experience shows that knowing about the capabilities of the supercomputer itself already helps artists to integrate these into their creative process. But being a more or less binary system that takes 0 or 1 digits as input and produces 0 or 1 digits as output, the supercomputer might be perceived as somewhat sober. It is mainly in combination with an output channel that is human oriented that the real value of the supercomputing power can become visible: visualisation as the widest channel for information.

The usage of an advanced virtual reality environment like the five-sided CAVE at the HLRS, allows the integration of the viewer into a virtual world, which through its interactivity, creates the illusion of being part of this world. Complex three-dimensional structures can be experienced as if they were almost real, especially through the tracking of the viewers' position and the related correction of the perspective that is used to render the scene. The interactivity is not only limited to the positioning of this viewer: due to the tight coupling of the visualisation system with the supercomputer even complex behaviour can be integrated into the scene, allowing the artist to bring things to their (virtual) life, that cannot be realised in a physical environment. This setup can be the portal to imaginary worlds, a completely new playground for artists!

Datami offers the environment to not only meet, but also to exchange and develop ideas. The intensive, workshop-like setup provides exactly the space and time that is necessary to develop the deeper bonds that form the basis on which new and exciting things can develop. This is the ideal constellation to open up the minds not only of scientists, but also of technologists such as myself, as well as artists.

Joint Research Centre
Ispra site
Photo Cristina Fiordimela

Digital Transformation – Can Reality Keep Up?

Michael Resch,
Director High-performance Computer Centre, Stuttgart

What has so often been predicted in computer technology has only recently led to a level of performance that allows for a long-planned – and rather often proclaimed - revolution to actually happen. With supercomputers reaching performance levels of about 10^18 operations per second, the digital world is starting to shape what we are used to call "reality" – without exactly knowing what we mean by it, but referring to it somehow as the world around us that we can perceive with our senses. This performance explosion in recent years, is accompanied by an even more explosive growth in data and information. Unlike Byung Chul-Han's concept of information, developed mainly to criticise the banality of the Internet as the pornographic polished surface of reality, information is becoming increasingly understood as it was originally defined by Shannon and Weaver: as that which is surprising. And there is a lot of surprise in the newly created digital world that surrounds us.

By creating digital realities – and not just a single one - digital transformation is starting to challenge our traditional concept of reality, as it starts to create a whole universe of realities. Each of these remain somehow connected to our traditional concept of reality, but at the same time to a new and unseen pre-reality with its own concepts of reference and meaning.

What Walter Benjamin observes for the work of art in the age of mechanical reproduction, is becoming the standard for all reality that we face. And more than that: like art, our reality starts to lose its fixed point in space and in time. The concepts of future and past disappear as well as the concept of location does. Contextualisation is no longer a concept of an entity being located in a system but rather a concept constantly changing its meaning being located within a rapidly and permanently changing lucid non-system. As a consequence, the concept of originality has to be put on the red list of extinction.

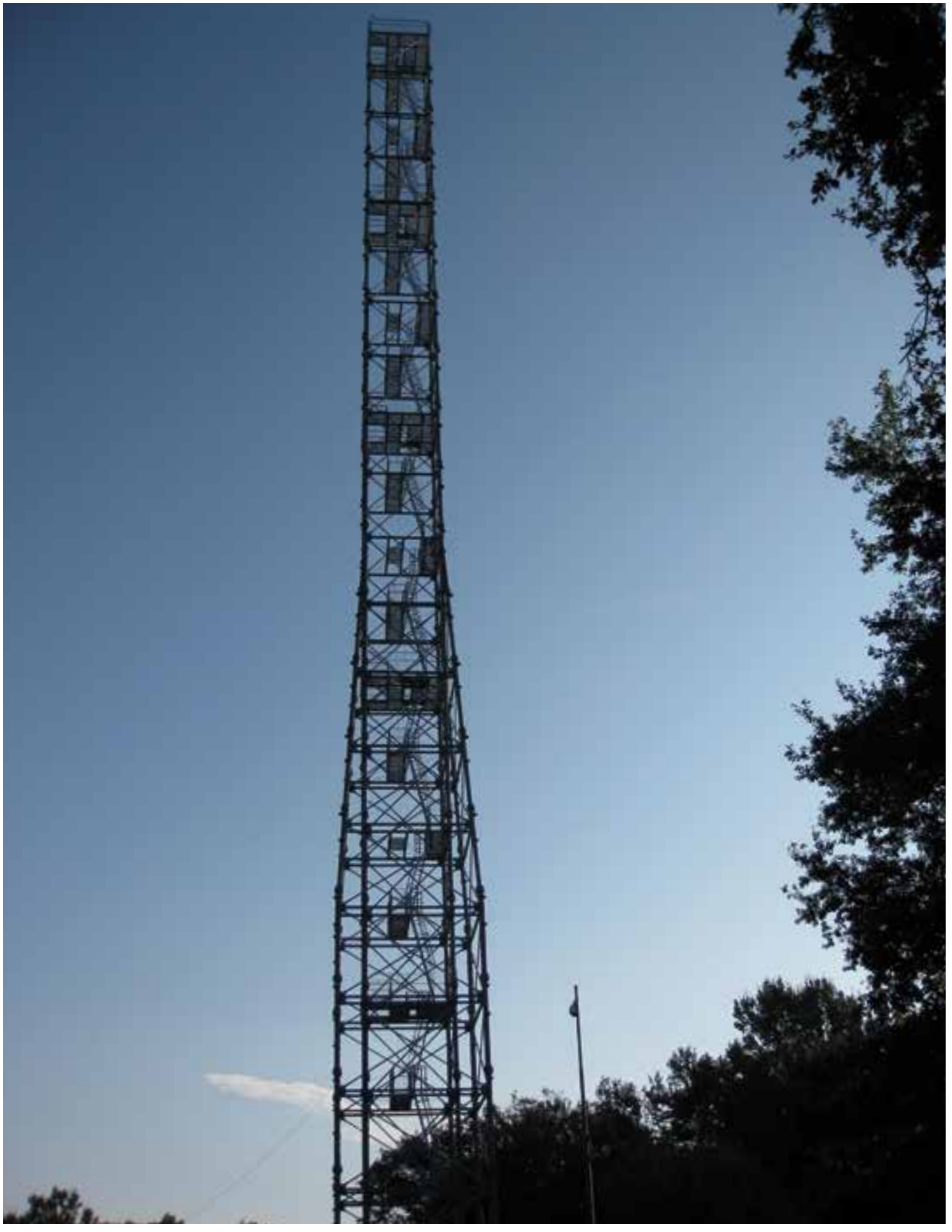
Already badly damaged by the concept of mass production based on standardisation and the elimination of everything that is not "normal", the origin of any digital artefact makes it even impossible to find that first mould that was used to create the infinite number of copies. A thorough analysis of the digital transformation has to conclude that digital transformation has killed "identity", leaving no more space for an identity based art or society.

This does not only challenge our concepts of intellectual property and individual ownership of an idea – at least in the western world, while the eastern world is much better prepared to live with the concept of permanent modification – it also brings our traditional concepts of art to the point of despair. What is the purpose of a museum if there is no longer an original piece of art? Even if we consider that museums are an invention of the modern world playing a very well defined role in a middle-class based capitalist society, we have to rethink art, its ways of presentation, and its (re-) production. With the inevitable question: what does this mean for the artist?

At the same time, digital transformation makes it impossible to define the normal version of an artefact compared to the non-normal versions. Replication and modification are not the exception in the digital transformation but become the new normal. One is tempted to say: the normal is the abnormal.

What is perceived as a challenge but also a chance in art and in science, is increasingly becoming a serious problem for modern societies. After 200 years of defining and shaping the world in terms of nations – with numerous wars fought over the purpose, meaning and role of that concept – digital transformation completely changes our perception of reality, to the point it makes regional, religious, linguistic, historical, and other classical distinctions meaningless. Instead of providing stable ground for identification within a fixed notion of nation, family, religion, language, society, and profession, digital transformation multiplies the already existing confusion of the modern human being with its many options to live its life. What was until recently considered a nightmare of options to find a path in, life turns into an even worse nightmare of realities to live in simultaneously. Not only motivated by the various roles that each of us plays in the various "orders" of modern society, but also because of the fluidity of any role in what we have come to call the digital society.

This causes pain, this causes confusion, this causes rejection – as has always been the case with new technologies. With all this in mind, we have to remember that we learned to cope with Gutenberg as well as with TV. The remaining question left with digital transformation is: what will "we" look like once the transformation is over? The global village of Marshall McLuhan is but a starting point for a journey that has only now begun.



Joint Research Centre
Ispra site
European Commission Atmospheric Observatory
Photo Cristina Fiordimela

Image Construction Site

Cristina Fiordimela, SciArt exhibition and graphic Designer

Breaking the silence
Of an ancient pond,
A frog jumped into water —
A deep resonance.

From Matsuo Bashō Haiku, translated by Nobuyuki Yuasa

Datami area as defined in "commoning"

The search for a Datami attitude with which to approach the JRC campus as a habitat for SciArt is still a work-in-progress, which continuously transforms how we perceive JRC space from a setting solely dedicated to research, to an existential dimension, to the coincidence of work-life. Moreover, the JRC community is not only scientific, it is in fact much more extended and particular when it comes down to referring to its territorial space. The JRC campus can consequently not be defined by the usual taxonomies of organisational types, such as "university campus", "research institute", or "scientific laboratory", and not even by that of a "managerial-administrative office", because it is, indeed, all of these as well as none of them at the same time.

Applying the shape-shifting Datami concept means committing oneself to a continuous dialogue with the experimental spirit of SciArt. To do so without the need to continuously define the Datami's contours, but rather by tracing the moments when it opens-up, has been a fertile period that allowed to cultivate the JRC campus as a field of knowledge, and as a newly writable area. The latter is axed around a new space for art that breaks with convention, where frontiers are defined as exclusive/peripheral, in a tension towards a concept of urbanism where art and life become indissoluble. This, we have done through the concept of "commoning", calling it "Art without table" (art sans table) in one of our latest performance-actions at ECA, the European Commons Assembly[1]. This resonating "commons-art" spreads out while passing through the JRC campus, as a relational space, where it becomes possible to reformulate "a common seed". This arises from intertwining the study of the art installations with the mix of languages, signs, intersections, and differently shaped volumes that punctuate the site, revealing the place's calling as a sensible habitat, porous to complexity. Thus, the JRC is revealed as a "commons-area" by this passage of SciArt, unveiling its capacity to cultivate knowledge jointly as a cognitive practice.

SciArt promenades, crossings, itineraries

During the SciArt residences, we traced the landscape as narrative, with multiple incipits, structured in a queer miscellany of cognitive materials extracted from direct experience on the field. Fifty-two kilometres of tracks on the site were explored, often taking us off the beaten tracks and roads: from the top of the meteorological. tower to the edge of the forest, where the ribbit of the Lataste or Italian agile frog, a rare species of red frogs, resounded on the surface of the human-like shaped lake.

These were the first signs harvested in the "JRC fields", from bodies and visions, as disentangled images from a kaleidoscope. We took the scientists on roaming walks, with stops, pauses, deviations, unexpected turns, and noticed how the rhythm of steps changed with habit once the paths became habitual. We noticed the flux of cars that cancels the curbs of the road, blurs them, confounding matter in a single amalgam that smoothens vision. We took the artists on the same walks, to measure distances and spaces, take photographs and be filled by wonder. Curator Freddy Paul Grunert invited them to expand their vision of the site, as if they were hovering and swarming above it like drones.

The site unveiled itself to us through the scientists and their memories: its intricate network of laboratories and buildings designed to practice science. Walls do not matter here – maybe there should not be any: the crossing is embedded within research as such, and connects the spaces as if it were a matrix that generates the landscape of the research field. It enables to transcend the stereotyped morphology of buildings – it is precisely in their modularity that is full of known associations, that resides a possibility of transcendence of these buildings: divisions, compartments and walls could hereby be replaced with silk screens. The new buildings use big glass windows or glass walls to enhance transparency and to respond to a wish to overcome the division between the visual and cognitive fields.

Roaming the site with scientists discloses a new way of orienting oneself across architectural or urbanistic limits: research paths are inter-connected, without uncoupling the place-instruments-research entities. It is a cognitive system that transcends views, and that, when touching art, enters the field of the Pictorial Turn, as described by W.J.T. Mitchell. He describes the concept of "Material Practise": in a world where everything is composed and where media, as well as scientific research tools, are relational networks[2].

Resonances III Datami
Datami Display
Exhibition Milano Digital Week
Palazzo Giureconsulti, Milano
13-17 March 2019
Photo Cristina Fiordimela

sciart
society

sciart
society

Cristina Fiordimela,
Logo of JRC SciArt, Ispra 2019

next page:
Resonances III Datami
Booklet Datami, Graphic Design by Cristina Fiordimela
Exhibition Milano Digital Week, Palazzo Giureconsulti, Milano
13-17 March 2019
Photo Cristina Fiordimela


The JRC
SciArt Project

Moving within this “dis-orienting” visual system is like walking with our eyes closed. In this blind environment, we defy conventions and move into what Mitchell called “visual literacy”, and which Eisenman explained in Digital Turn in Architecture . In the text *Architecture After the Age of Printing*[3], Eisenman states, “Architecture will continue to stand up, to deal with gravity, to have “four walls”. But these four walls no longer need to be expressive of the mechanical paradigm. Rather they could deal with the possibility of these other discourses, the other affective sense of sound, touch and of that light lying within the darkness”.

SciArt_Datami Design-field

Artistic engagement gives rise to other fields of work, involving experimentation with a range of approaches. The common thread binding these experiences in the field together is the simultaneously artistic and scientific motion/movement that drives the work. Curator Freddy Paul Grunert refers to this as the SciArt agora, involving a “peripatetic crossing that redesigns the intersection, a sort of *Urzelle* (primordial cell) for a new form of citizenship, from which life, rules, desires, curiosity and harmony extend, in an Aristotelean sense”. The SciArt intersection manifests initially in the design field, involving the creation of an ad hoc image to accompany the SciArt word. The composition is achieved through the sliding of one field into the other, until the signs merge to form a single, ever-open “hook”, supporting the concept of agora as crossing.

The resulting SciArt image is a sort of rewriting in the field, be-coming uncoupled from the logo to move into the locus.

The pursuit of dimension-Datami-agora is conveyed with reference to Kuki Shûzô’s *Structure of iki*[4], which manifests itself here as “a sidelong glance, the ability to combine spontaneity and artifice”, towards *iki/sui*, the essence. Such considerations – combined with the pursuit of dimension, initially emerging in the spatial matter-form unity of the sun, the tatami matrix – give rise to the Datami image, intended to evoke the data-embodiment tension, with a simple, candid sentiment that withholds disdain.

Resonances III Datami
Outdoor graphic display
Set up
Festival JRC Ispra site
15 October-8 November 2019
Photo Ulrike Miriam Baush

Resonances III Datami
Visual Identity
Festival JRC Ispra site
15 October-8 November 2019
Photo Siobhan McDonald

The subject of the JRC's SciArt Datami interstitial redesign project is the image, and its infiltration of the "field" where surfaces serve as a palimpsest.

The surface is the matter-image, the film, the indistinct dissolution of the projection in the air, the face-aspect, surface as subject of the inherent and deformable image, with reference to *Surface: Matters of Aesthetic*[5] by Giuliana Bruno , and the aesthetic of the invisible explored by Pavel A. Florenskij in his writings on iconostasis. At the JRC, matter-image flows into site-image: a system of images oscillating between the artefactual existence of the remains of post-nuclear work and the becoming of sites that, by way of a series of accelerations and decelerations, continuously reset the architectonic arrangement of the space. The redesign of the SciArt_ Datami space takes advantage of the changeable nature of the sites from which it draws its impermanence, the incompleteness of a space with borders that are constantly changing to redefine the space where the opera is produced. And, in a more general sense, it is the work-site in the field, understood as a research centre and common space where scientists and artists work together on the opera. The concept of site here encompasses the notion of a framework, a supporting structure designed to be destroyed. The sense of incompleteness, ephemerality, suspension, also extends to the interaction with laboratories: the photographic images, taken by the artists during their residencies, are treated like museum items, some testifying to work that is no longer ongoing. The composition of the image therefore operates in the same way as in a museum, occupying the glass surfaces of the dividers, the plaster of the walls and the floor, to produce a palimpsest_museum, an agora_space of shared rewriting, expanding the concept of museum_medium discussed by Roger Silverstone[6].

The relief of the space therefore presents a system of spatial relations, driven by a desire to move beyond cartographic representation, with a swarm of drones flying overhead (the visionary image of the curator to accompany the "outside" inside the campus).

Vegetation is by no means a secondary feature of the research site. It looms over human activity, creating unexpected visual crevices, reinforcing the sense of limitless cognitive discovery, which operates within the paradox of a series of openings with boundaries that one is mentally aware of without, however, ever being able to grasp their full extent. And the vegetation – and the orography of the site more generally, with dense wooded sections that thin out into glades, sometimes wild and partially hidden, and home to native species that are rare

Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Selections of demanding SciArt works at Bozar:
Quantum Oscillographs, Photo Cristina Fiordimela
To Breathe, The Tannhâuser Gate, The Making of Datami: a draft diary,
Silicon Synapse, Gaia 5.0, To Breathe, Photos Riccardo Pareggiani
IN|de|Finite, Photo Cristina Fiordimela


Solicitation
mi

both in terms of their biological mutation and the protection of their natural habitat – provides the pretext, the SciArt artifice that serves as a fixed yet simultaneously weather-changeable keystone, of the interstice_image system that goes beyond the human understanding of the human.

"Humans have always been radically reshaped by the designs they produce and the world of design keeps expanding. We live in a time when everything is designed, from our carefully crafted individual looks and online identities to the surrounding galaxies of personal devices, new materials, interfaces, networks, systems, infrastructures, data, chemicals, organisms, and genetic codes. The average day involves the experience of thousands of layers of design that reach deep into our bodies and brains. We literally live inside design, like the spider lives inside the web constructed from inside its own body. But unlike the spider, we have spun countless overlapping and interacting webs. Even the planet itself has been completely encrusted by design as geological laser. There is no longer an outside to the world of design. Design has become the world[7]."

The JRC is part of this world. It's not re-design of the human, it is art science policy landscape structure knowledge pleasantly diving in landscape. The site_ image is a visual dis_orientation that provides the opportunity to move through a system of complex references, transcending cartographic representation, the numerical identification of buildings, the bijection of accessible routes. I insert the curator's correlated traces of Resonances printed like crosswalks to connect the diffused installations: R: Reverberations/ E: Eigenstate/ S: Shift shaping/ O: Oblivion/ N: Nearest neighbours/ A: ad hoc assumptions/ N: Negentropy/ C: Contingency/ E: Erasure/ S: Solicitation.

The essential feature of the Datami matter-image is the SciArt open hook. The walls are opened up by the closing of the windows covered in images: images of the SciArt project, images of the laboratories. The laboratories are connected by a system of images that reconfigures the site, working on the horizontal plane of the facades to draw them together on a single sheet, that visual-cognitive unity within which the scientists move every day.

It is a single suspended field, unshackled from the gravity of the walls, attaching itself to the barely perceptible motion of the trees, to understand the notion of intertwining, of the cognitive forest of images, transferring the cognitive emotions of the virtual environment discussed by Christa Sommerer and Laurent Mignonneau[8] to the situationist physicality of that defined by Paul Ardenne, in *Un art contextuel*, as "art de la mobilité, art de la matière, de l'instance et de l'action propice à développer chez quiconque s'y trouve confronté des sensations mentales, visuelles, obligeant à repenser l'ordinaire de l'esthétique[9]" .

The walls are covered with simple paper posters, torn by the wind and soaked with water, alluding to their inherent ephemerality. And so perhaps the matter-image becomes the eternal-present: the present infinitely dilated of back-ends, of the lapses, of Yasujiro Ozu's transcendent cinema, of editing, of deconstructed-assembly, taken apart and put back together, of spaces between the branches where the empty space is an integral part of the form: digital matter becomes physical image.

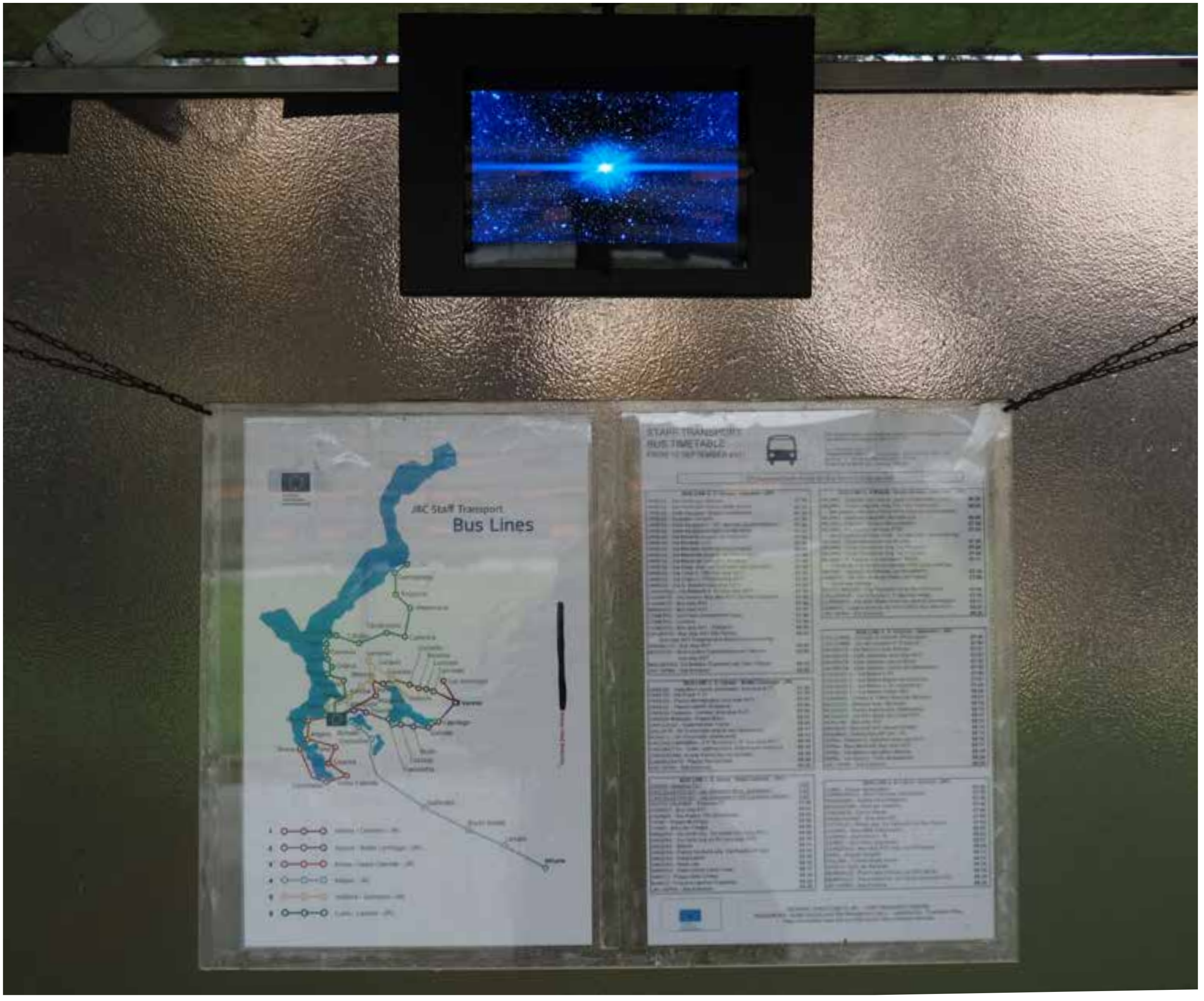
The Datami Book

The Datami Book gathers experiments that share artistic as well as scientific aspects geared towards Investigation, and the display applaid in the book is an endbook to SciArt.

Following curatorial indications, though, the Datami book reveals the encoding of a European institution with its cognitive networks and social relations. Even more, it discloses the connection between landscape, laboratory and SciArt results, in a condition of dissemination and non-permanency. One could define it as a book of fleeting forces, where the design of the book establishes a correlation between the passage of the Datami landscapes on the JRC site as an museum of research, an active archive that blends production, exhibition and work, and so finds, within the book, room for a layered organisation, using inserts: a post-human filing cabinet.

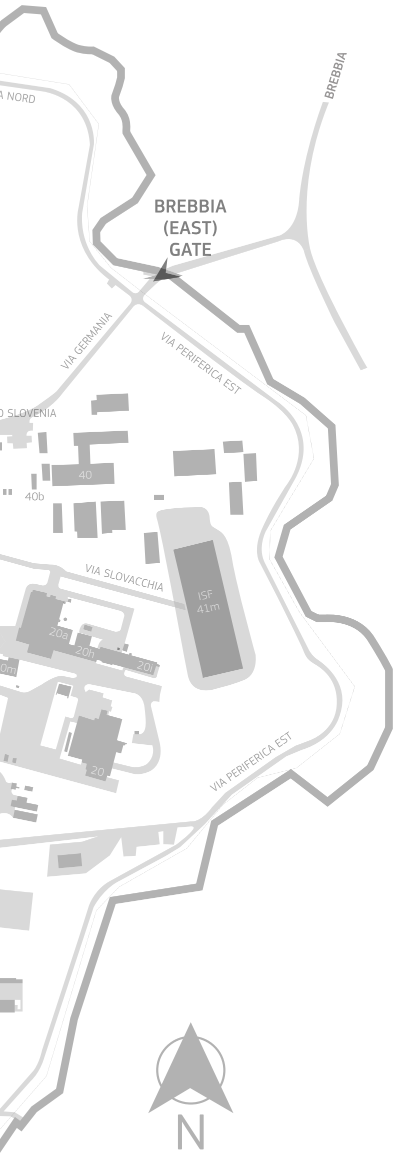
Notes

1. Cristina Fiordimela and Freddy Paul Grunert*, De la Chambre d'amis a la Chambre en commun. Art sans table*. «Les cahiers de culture & démocratie» 8, Culture&Democratie ASBL: Saint-Gilles 2018
2. W.J.T. Mitchell, *Picture Theory,* Chicago-London, University of Chicago Press, 1994
3. Peter Eisenman, "Architecture After the Age of Printing [1992]", in *The Digital Turn in Architecture 1992-2012,* edited by Mario Carpo, 15-27, Chichester, John Wiley & Sons Ltd, 2013
4. Kuki Shūzō, *La struttura dell'iki,* a cura di Giovanna Baccini, Milan, Adelphi, 1992 [1930]
5. Giuliana Bruno, *Surface: Matters of Aesthetics, Materiality, and Media,* Chicago, University of Chicago Press, 2014
6. Roger Silverstone,"The Medium is the Museum," *Towards the Museum of the Future: New European Perspectives,* ed. Roger Miles and Lauro Zavala, London: Routledge, 1994, p. 164
7. Beatriz Colomina & Mark Wigley, *are we human?,* Zurich, Lars Müller Publishers, 2017, p. 9
8. Christa Sommerer and Laurent Mignonneau, *Art@Science,* Wien and New York, Springer-Verlag, 1998
9. Paul Ardenne, *Un art Contextuel,* Paris, Flammarion, 2002, p.163. Own translation: "art of mobility, art of matter, of the moment and of the action suitable to developing within each of us confronted with it, mental,visual sensations obliging us to rethink the ordinary nature of aesthetics".



Resonances III Datami
Rebecca Ballestra, Nikolaos Stilianakis,
Conversation on Time
Festival JRC Ispra site
15 October-8 November 2019
Installation view in the Bus Stop
Photo Cristina Fiordimela

ISPRA
VIA PERIFERICA OVEST
VIA PERIFERICA NORD
EMEP 77r
VIA ESTONIA
VIA UNGHERIA
VIA GRECIA
VIA LUSSEMBURGO
VIA FRANCIA
VIA CIPRO
VIA FINLANDIA
VIA AUSTRIA
VIA DANIMARCA
VIA BULGARIA
PIAZZA LETTONIA
VIA BELGIO
VIA MALTA
VIA GRAN BRETAGNA
VIA GERMANIA
VIA ITALIA
VIA PORTOGALLO
VIA OLANDA
LARGO ROMANIA
VIA IRLANDA
VIA REP. CECA
VIA PERIFERICA EST
VIA SVEZIA
VIA SPAGNA
VIA FORESTERIA
Via Esperia
Via Enrico Fermi
STAZIONE GAS METANO
ZONA-IACP
CUSTOMS GATE/GOODS DELIVERY
ψ 18
ψ 17c
ψ 17
ψ 58c
ψ 8 bus stop
ψ 26a footbridge
ψ 24a
ψ 100
ψ 48
ψ 46
ψ 46i
ψ green area
ψ 6
ψ 67
ψ 1
Life Science Building
Environment Building
Parking place
MAIN ENTRANCE
BARZA
CADREZZATE



ψ 01, 06, 08 bus stop	Conversation on Time
ψ green area	In|de|Finite
ψ 17	'Life is Motion'
ψ 17c, ψ 100	Forever-do
ψ 18, ψ 48	Nature of Knowledge - The Uncertain Structure
ψ 24	Silicon Synapse
ψ 26a-100 footbridge	"Why Am I Seeing This?"
ψ 46	Landslide, The Price of Volatility
ψ 46	Portrait of the AI as a Young Cyber Oracle
ψ 46i	horaica
ψ 46i	between systems and selves
ψ 58	3 poems [e e cummings] - world premiere
ψ 67	B-Scope, C-Index
ψ 67	To Breathe
ψ 67	D. pulex Black Box
ψ 67	The Sound of Waves
ψ 67	GAIA 5.0
ψ 67	Retinitis Pigmentosa
ψ 67	Quantum Oscillographs
ψ 67	Weather Prediction by Numerical Process - a Forecast for Europe
ψ 100	My Data and Me: una storia d'amore
ψ 100	The Tannhäuser Gate
ψ 100	DataWe
ψ 100	Resonances Space - Interactive Big Data Sculpture

ψ datami disseminated
on the Joint Research *Campus*

Datami Occupancy SciArt Opera: map of Datami Festival & Exhibition in the JRC Site Ispra, graphic design by Cristina Fiordimela.

The graphic design of map takes inspiration from the research 'Monitoraggio della popolazione di Rana Latastei all'interno del JRC Ispra Site' (Monitoring of Rana Latastei life in JRC Ispra Site), report of Silvia Macchi and Stefano Scali, Green Areas Management, May 2018.

The symbol ψ of the occupancy model, is based on data of likelihood, from the research of Rana Latastei and adopted in the Map to indicate the diffused occupancy of Datami-unfurling in the JRC site. The Rana Latastei proceeding is adopted to design the Datami_residencies in practice as an open post-human porous - non circumscribable - interstice of occupancy between landscape, inhabitants, buildings, infrastructures in the JRC.

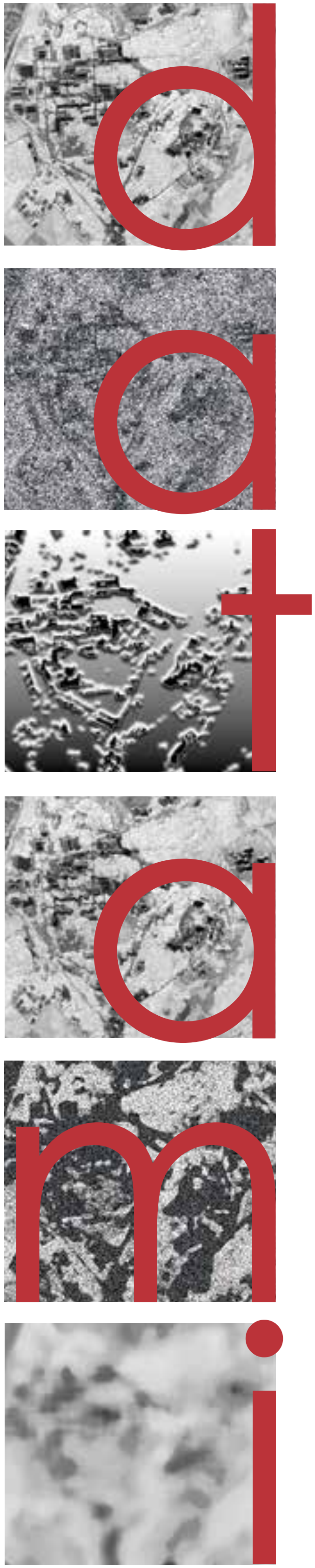
On Presentation

Adriaan Eeckels

We chose six words to symbolise the Datami, six words that capture different aspects – not necessarily of easy understanding. They are and should be mysterious, intriguing, frustrating, contradictory, fleeting, evanescent, in the end: quite ungraspable. They symbolise road signals into a new world that is emerging but not really clear, yet we feel it has already swept away the old one, a new world where some expect anthropological changes, some dream of immortality, some others fear an intelligence that will treat us like we treat trees, new overlords that will prune us at their whims. Some see a split world with the advent of new species, merely digital cohabiting with the human, steel married to flesh or steel separating flesh, a world where human becomes suddenly a complex problem, whether because we now know not so much that civilisation is mortal, but that the demise of man is a distinct possibility emerging at the horizon. We see reality shifting in an explosion of viewpoints, we see many realities in a blossoming multiverse as close as I am to you yes even closer, we cannot stick to one viewpoint only, we cannot make it cohere. Boundaries are shifting in a multi-coloured aquarelle of hybridisation, a kaleidoscope of possibilities unfolding under our hands.

We treat these words like rallying flags, mere pointers to nowhere, suggestions that should not close the horizon but help to open it up. They classify without closing, they can be replaced by any other concept, as long as the new concept captures this shifting world, the shifting sands of change moving beneath our minds and senses, this growing datasphere which we have to come to love and loath in different measures. Like the Datami they arose from, they are an invitation to keep the mind sharp, our understanding wide and clean, indicating without closure, opening without end.

We then played a game of non-knowing, putting the works into each non-category. Why should this work be an Agency and the other a Maze? This one Inflation and that one a Twist? It is an exercise in feeling, and as any feeling, words fail. It is because words fail that we cling to them, and our clinging might be fleeting as foam on a setting sun in the sea.



Resonances III Datami
Visual Identity
Keywords
Graphic design by Cristina Fiordimela

The Environment Within

Ignazio Licata

The Environment Within

An epistemological reflection on the concept of the border

I. Premise: on the difficulty of tearing down walls, if walls are spectacles

The history of transdisciplinary relations between hard and soft sciences is richer by its skirmishes than by its encounters. Developing a certain epistemological sensibility became a necessity, to knead and soften what was always perceived as a dichotomy. On the one hand, the hard sciences, by grace of a method stolen from some trans-Uranian, drill down progressively into reality uncovering its "laws", which are then ordered in an asymptotic succession that points directly towards a "theory of everything" – this purely mathematical "Eye of God" from which everything can be derived; on the other, the soft sciences investigate, with some cumbersome empiricism, the complexities of a multi-pronged subject that is invisible to the physical world. It should be evident that this refers to the classic Cartesian theme of res cogitans/res extensa[1], often contested but by now pervasive and insistent in the collective imagination as well as its natural corollary of the "two cultures"[2].

And yet, the philosophies of the object and subject have a history of coming together. They can be seen as poles of a continuous gradual range of attitudes towards the world, rather than as opposites. These attempts are little known. We could say they constitute a subterranean history except when one of them is brought out at the occasion of some festival and, more generally, in all those occasions wherein the media make false reconstructions of the contradictions and contrapositions that are part and parcel of our personal and social lives. It is difficult to tear down walls when those are not made of good old bricks but of cognitive lenses. On the scientific front, we have to call to mind, in this context, at least the systemic-cybernetic tradition, and especially Norbert Wiener, Ludwig von Bertalanffy, Gregory Bateson, Heinz von Forster and, as a matter of fact, the beautiful and mature results of the collaboration between Humberto Maturana and Francisco Varela[3]. It is arich and extremely complex branch of thought, but to our ends it is sufficient to observe that the "platonic" approach to the world is substituted by a more realistic vision, much closer to scientific reality and situated within a precise historical and social context (and thus not less socially embodied than its representatives). It is also driven forward by a plurality of micro paradigms that can adapt to knowledge objectives, and are fine-tuned to the concrete problem that is being studied. The "physicality" fails as knowledge model for all sciences, while the epistemological specificity of each single discipline is being recognised. The issue of the subject isn't a scandal anymore, in stark opposition to the material sciences, to which they have the same relation as the so-called limit and boundary conditions of mathematics. The latter are necessary to resolve an equation, to confer a "here and now" to a general structure of relations. In the end, it is precisely the apparently innocent "here and now" that makes the difference between hard and soft sciences; the former deal with those aspects of reality that can easily be extracted from the "clump" of daily events – as C.E. Gadda would say – and can be expressed in mathematical formula, invariable in time and space. When the "here and now" cannot be abstracted, that is, when the historical facets of a system enter into play, the soft sciences are better equipped to describe the world. The renowned complex systems are systems in which the conditions wherein an event occurs can even be more important than the "laws" that govern the class to which the event belongs.

Moreover, let us not forget that in the majority of cases we are called not only to describe the world and make predictions, but to understand and to manage it. As Marcello Cini wisely observed, in ideal traposition disappears, that between case and cause. The famous "scientific laws" are actually grids of possibilities wherein a single event occurs (this is simply the etymological root of the term case). Indeed, those disciplines studying complex systems, from biology to psychology, confer a special importance to the occurrence of a single event. There are no general laws to be found on evolution or on conscience because of the simple fact that these represent histories, processes, not simply immutable configurations of events.

Literature, from its part, as prime representative of the subject, has more than once reached out to science, to underscore the substantial convergence between subject, observer and inventor of theories and stories. Here too, the list can become long: the natural philosophy underlying the two masterworks of Stefano D'Arrigo *Horcynus Orca* and *Cima delle nobildonne* (*Peak of Noble-women*), *Ratner's Star* by DeLillo, *Smilla* from Peter Hoegh, the many posthumous Majoranas remade by the various Ettorologists, the recent *Solar* by Ian McEwan… And then again Leonardo Sciascia, Italo Calvino… we leave a more detailed exploration to future investigators of the virtuous relations between science and literature[4], and we limit ourselves to a single quote from *Atlante Occidentale* by Daniele Del Giudice. Together with DeLillo, Del Giudice has shown how literature demands a rigour that is not too far away from scientific rigour, with its need to bring structure in a series of precise choices of themes, registers, and internal harmonies. The writer tells the physicist: "When you are looking, do you still manage to see the things, you who are working on the absolute disappearance of things! (…) Doesn't he see that the things that are coming into being, that will be, are pure energy, pure light, pure imagination?"[5]. The answer could come from David Bohm, and goes to the heart of the question: "A change of meaning is a change of being (…). There is no fixed or definitive meaning. The question of meaning is entirely determined by the fact that meaning is immersed in a context, which on its turn is immersed in a context, so there is no final meaning. It is a process of unveiling that in itself is a part of reality. (…) Meaning gives form to all things"[6]. A description of the world, whether it takes form from concepts determined by complex equations or by the choices of writing, is always a series of choices within a certain vision of the world.

II. The Environmental Issue: "Out there, beyond me"

This long epistemological premise is necessary to grasp, in its entirety, the tremendous problem of the environment. In the systems approach, we separate the system from its surroundings by means of an ideal line. This is the starting point of any science, and, by extension, any narration. The hard sciences (but by now we know that this term indicates a procedural choice, which is a virtue in the original sense of attitude and quality) select and specify a series of relationships between environment and system, governed by a few parameters. This is not possible in cases of greater complexity, which then are the overwhelming majority of that which surrounds us. Or more precisely, this line is not continuous and closed, but it is a variable border of openings, a fractal that remodels itself continuously through a game of interrelationships where the border itself has faded. In the end, we recognise as a deed of hubris that theoretical gesture of drawing a border between in- and outside, between a system and its environment, between character and story.

So it is possible to review all that we have premised as to border and its dissolving in a direct and simple, yet extremely thin, manner. The range of disciplines and knowledges goes from physics – mathematics, that has a clear vision of the border or at least, one that is always definable; it then passes the many degrees of widening logic when coming to life sciences and cognitive sciences, to economics and sociology, and at certain moment this border, that regulates the passage of information, even becomes sensible and porous to different meanings It is finally remodelled by these meanings, and in the end, disappears when arriving at the "humanities", where it is the meanings themselves that fix time by time the needed borders, and that organise the narrative planes. In this manner, we find back the polarity between the two cultures, but we resolve their disputes, because what is at play are not two alternative visions expressed by necessarily opposed languages that exclude the one from the other, but two legitimate choices of resolution of the border; the physicality claims borders capable of resolving the relations between system and environment in such a way that it can, in the end, enumerate a series of information bits on classes of possible events; art and literature, at the opposite side of the range, resolve the issue of the border dissolving it in the irreducibility of the event and its meaning.

The relations between an environment that is objectively "already there", governed by the laws of the material world, and a subject-system irreducible to these laws, now offers a different perspective of resolution. It is a matter of elaborating a new visio on the border, close to a "theory" but this time "not of everything" – it is rather a unifying theory of observer and observed, capable of giving expression to the plural vision of the border where we find ourselves. From the scientific point of view, there are already strong suggestions in that direction, like the structural coupling of Maturana-Varela, or the theory of logical opening[7]. On the literary front, the most extreme example can be found in the *Trilogy* by Beckett, where not only space and time but also the identity itself of the voice overlap up to the epilogue: "Maybe they brought me to the threshold of my story, in front of the door that opens to my story, that would surprise me, if it opens, it will be me, it will be silence, where I am, I don't know, I will never know, in silence one doesn't know, we need to go on and I will go on". It is interesting that Aldo Tagliaferri in his preface makes a reference to the "quantistic"character of Beckett's writing. Indeed, a theoretical suggestion to investigate this subject comes directly from the "hardest" science, quantum physics. It is the theory of the Quantum Brain developed since the sixties by scholars like L.M. Ricciardi and H. Umezawa, developed more recently by Giuseppe Vitiello and his collaborators[8].

III. Dissipative Quantum Brain: intertwined with the world

In the historical 1967 article *Brain and physics of many-body problems*[9], Ricciardi and Umezawa propose a revolutionary quantum model of brain activity, developed in analogy with the field of Condensed Matter Physics. The genial keystone of this work is bypassing any na.ve isomorphism between neuronal structure and the model. Here indeed, "quantum" must not be understood as "something strange in the head" (which is more or less the common acceptation since the famous book of Roger Penrose[10]), but a formalism capable of describing very complex collective behaviour. The objective of Umezawa and Ricciardi was that of providing a model of memory as a global dynamic activity, in a decisive alternative to the digitisation of the mind starting in that period and just before the impetuous developments in informatics. It is enough to know that external stimuli trigger, within the Quantum Brain, a configuration of quantum modes that correspond to the cognitive functions codified within these modes. The model explains in a simple and direct way some essential characteristics of mental activity, like the selective and sequential recall of memories. On the other hand, the model is intended to be a so-called "toy-model", a theoretical game, a seminal scheme of possible lines of future research. Indeed, the hypothesis of a closed system, confined in a finite volume, offers only the possibility of overwriting memories, but not of describing their progressive decay and their superimposition.

So, it becomes necessary to take one further step and introduce opening and dissipation. In the new model, the complex game of processes linked to the exchange of energy and information between system and environment replaces the image of a closed mind that exchanges information with the environment, with that of a mind that lives as part of a unique process of phase transitions and emerging levels. Introducing dissipation implies, in fact, to consider mind and environment as a *single system*, taking out the brain from its vase (H. Putnam). In this way, we can give a precise meaning to the expression of *embodied mind*, adopting a model at high level of logical opening, consisting of breaches of symmetry, bifurcations, and emergencies. It is the mathematical structure itself of the theory that allows for the coexistence of infinite coherent and non-destructive states. New information does not destroy old information, but remodels it and disorganises it partially as one would expect in a dissipative system. Without dissipation, there is no place for new thoughts. In this way we obtain a natural arrow of time that is compatible with the historicity of cognitive systems.

This formalism has an appealing aspect that is useful to point out here, without going into detail. In the theory, a key role is taken by two sets of modes that we will denote as Ak and Ak, with k grades of freedom of the field. These two structures are deeply connected;. in particular can be considered as the time-reversed image of mode A, being the inextricable reflex of the environment on A's structure. Vitiello has called it the *double of A*, or *its stand-in*; he has suggested that it can play a significant role in explaining conscious processes as a special property of *auto-interaction* of the system with itself through the world[11]. It is possible to say, in agreement with Maturana and Varela, that mental activity is a continuous *production of the world* that takes its origin from the irreversible and dissipative nature of our interactions with the environment. It is also important to draw attention to the circularity of the process: the produced world must *first* have been *introjected* and elaborated within the cognitive schemes of the observer-agent. In other words, the environment is not anymore something that is "out there", but it is a product of cognition, first subjective, and then collective.This also puts some strong limits to a mere computational vision of the mind and language[12]. As often happens when scientific research is "solid", its tiles demonstrate that they can easily fit in with those of other origins. We do not only refer to the work of Vitiello in the last years with neurophysiologist Walter Freeman (1927-2016), but also to the semantic appropriation that already begins with the perceptive fact as demonstrated by cyberneticist Peter Cariani[13].

IV. Ecology and, in the end, Aesthetics

The profound modifications of the archipelago of scientific knowledges implicit in a complex concept of the notions of system and environment have many consequences – also in territories that are apparently far away from research practices, proof that the cultural texture of out which any specific production emerges is one and the same. In a beautiful article of some years ago, Hans Jonas asked if "God is a mathematician?"[14]. Contrary to modern trends inspired until today by the most coarse divulgation, he answered decidedly "No". He anticipated the embodied contextualism of life with respect to the "universal" abstractions of physics and mathematics, denouncing the epistemological damage provoked by a strict separation between material "objectivity out there" and subjectivity. Whatever the case, we cannot see through the "Eye of God" and we are – to use a happy phrase from Nelson Goodman – "producers of worlds"[15]. Mixing the quantum terminology of Bohm with the images of Gadda, it is possible to affirm that out of the "gnommero", that is the mishmash, of the inextricable coupling of mind and world arises the production of a multiplicity of things, one for each observer. The environment is not anymore a thing "out there", to explore with the spirit of a positivistic coloniser, but the exact mirror of our conception of the world. By this, we do not mean any form of "relativism", the material world does not in any way lose its substance, its capacity to resist our theories and narratives – and to feel this resistance is not more than a virtuous sign of good science, as well as of good art and good literature. We simply want to acknowledge that we tend to adapt the world to our representations, not only on a theoretical level but also and foremost in a technological and economic sense. The image of the jungle of Salgari[16], the gardens of Versailles not less than domestic or circus animals are expressions of a concept of "nature" that iinseparable from the economic projections of the observer-agent. Any discourse on sustainability, ecology, speciesism must have, as epistemological postulate, that the "taking care of the world"invoked by Elena Pulcini's beautiful article[17] begins with displacing the axis and direction of the border – undoing from within the complicity between narcissistic individualism and the self-satisfying communitarianism that, together, produce unhealthy visions of the world.

In the end, as in the beginning, it is always a question of beauty. Which might save the world, on condition that we know what we are talking about. Not the beauty of a Like on Facebook, not that of a passive approval of art or of historicised science, "spoken" and judged even before it has been lived and understood. True beauty, in each field, is realising how, in a given historical and cultural moment – if our eye is sharp and our understanding wide and clean – that possible moves are never infinite as it might seem to the eye of an amateur, but that the efficient ones are in reality very few. And amongst these, those that can be realised are even less. If one adopts this criterion of beauty, a lot of the detritus and ghosts that wander through the mainstream meshes of our time are compacted and acquire the consistency of an unexpressed request, which in final analysis concerns the sustainability of our own sensitivity. Before wondering if "out there" – beyond the border that separates humankind from the environment that he has produced – it is possible to construct a different harmony, one has to ask oneself if we are simply capable of truly desiring this harmony.

Notes

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4. Yet something telling already exist, see Malvaldi, Marco *L'infinito tra parentesi,* Rizzoli, Milan, 2016.
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11. Vitiello, Giuseppe, My Double Unveiled, *The Dissipative Quantum Model of Brain,* John Benjamins Publishing, Amsterdam/Philadelphia, 2001. See also: "Essere nel mondo: Io e il mio Doppio", in *Atque,*Vol. 5, Nuova Serie, 155-176, 2008.
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15. Goodman, Nelson, *Vedere e costruire il mondo,* Laterza, Bari, 1988.

databodied

Embodied in data, Neuromancer, inhabitant of the digital, data boiling over into reality, reality seeping into the digital, borders falling away, uncertainty and uncertainties, a horror vacui married to the fear of the unknown, the future, heating atmospheres while we think of our next meal, forecast and computing power, computing and raw power, satellites thick with images, images streaming to the earth, can databodied be embodied?

The Tannhäuser Gate

Weather Prediction
By Numerical Process -
a Forecast for Europe

The installations in this section talk of life spilling over into new formats, the dream, not the nightmare of the cyborg or the AI, a world where we might live in silicon or in machines, not as a punishment but as a new human adventure. Even as we talk of beneficial AI, shouldn't we put the question if AIs and drones get human rights? Are we before the most portentous expansion of the idea of human, while we still cannot give rights to the ocean, to nature, to Gaia the Parliament of Being? How human are we then, still striving to become human – hominescencing – in our adolescence, like adolescents merely on the threshold of meaning what it is to be human? More than everything, the term databodied is a matter of uncertainty, a case of not knowing, a question, a finger pointing to the moon: how beautiful can these databodied experiments be?

B-Scope, C-Index

Nature of Knowledge -
The Uncertain Structure

The Tannhäuser Gate

Artist
Giorgio Sancristoforo

Scientists
Valentina Paracchini
Paolo Peerani
Mauro Petrillo

Collaborators
Andrea Cerrato, Assistant of Artist
Cristina Fiordimela, Executive design
Luca Pagan, Assistant of Artist

The Tannhäuser Gate,
SciArt Datami project, 2019
Sound Sculpture: 2-channel sound installation,
two pillars, 235 x 60 x 60 cm
Mixed Media: Aluminium, wood, electronics,
radioactive isotopes [Sr90]

To Chérie,
because you've always encouraged me,
I dedicate you this rite of passage
Giorgio Sancristoforo

The Tannhäuser Gate,
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Installation view
Photo Daniel Djamo

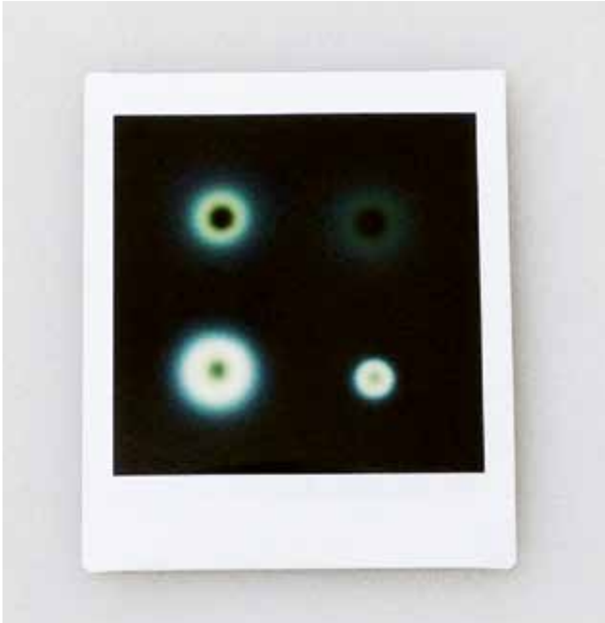
Foreword by the Scientists

Valentina Paracchini, July 2019

When I listened to Giorgio and his music for the first time, I thought: "He is crazy… I like him! If something can come out of the interaction between art and science it has to pass by him."
And so it was. The radioactive guy lent his musical ear to molecular biology and produced a unique creation. With a fluidity typical of a song and a speed of thought equal to that of radiation, he dragged me into his wonderful idea, and I welcomed his invitation to transformation with open arms. The project was defined over a very short time period. With a constant collaboration between all of us, powered by the passion that Giorgio transmits in his work, involving us to the point that we could not do without it. Driven by his enthusiasm and desire for knowledge, I exchanged the data of Giorgio's genome with graphics dense with codes and formulas that have stimulated my curiosity. I would have never thought that the work of a scientist could become art, and now that I've experienced it on the level of conception, I can't wait to see the work arising in its magnificence. Giorgio has given a new and completely different meaning to my everyday work, the study of DNA. He has transformed it into music and colours, so that everyone can perceive it.

Paolo Peerani, July 2019

It's not the first time for me, but dealing with artists and trying to match Art and Science is always a new experience. Probably the main difference between Art and Science is that Science requires reproducibility to confirm the hypothesis, striving for predictable results. Art aims to surprise people, create new and fresh emotions, and follow unprecedented routes of eternal change. However, I would like to focus more on the many similarities between Art and Science, and I call as a witness the poet John Keats. In his *Ode on a Grecia Urn* he concludes by saying:



Giorgio Sancristoforo,
Autoradiography Eu152, Ba133, Cs137,Sr90 Fujifilm Square, 2019

Beauty is truth, truth beauty,
that is all ye know on earth,
and all ye need to know.

Beauty and Truth: the attributes of Art and Science. Indeed what is Art, if not the Science of Beauty? And what is Science, if not the Art of Knowledge (and therefore of Truth)? This is what we get when Art meets Science, and this is what I hope everybody will see looking at *The Tannhäuser Gate*: Beauty and Truth.

Mauro Petrillo, July 2019

When I met Giorgio for the first time and discussed with him about the potential relationship between Music and DNA, I had the impression that he was not so interested. Then, the day after, he came back to me and Valentina saying, "Guys, I want to work with you, I have everything in my mind!" I was really astonished. What happened? I think what happened is that some

Study materials: Fiestaware pottery piece, Uranium, Thorium gas mantle, Photos Giorgio Sancristoforo

of his genes slowly switched on and a cascade of reflections flooded his mind, which all together gave shape to a visionary and marvellous idea.
Jokes aside, I feel lucky that Giorgio resonated with me as a scientist. Thanks to this experience, I now look at DNA with different eyes: I was already aware that DNA is not just a “long string made by only four letters” or a “series of nitrogen-containing bases organised as double helix”. I already knew that DNA is a pattern, the pattern of life. Now, thanks to Giorgio, I have learned that other patterns exist, which are equally significant and universal, like those of music or light. Thanks to Giorgio, I can now perceive DNA as the universal pattern of life to be listened to, rather than to be read. In a few words, thanks to Giorgio I learned how to feel the universality of DNA, which is my passion. If a man can feel his passion, then he is a lucky man.
Thank you Giorgio for making me feel my passion – now it seems that I was blind before meeting you.

Valentina Paracchini
while starting the DNA
extraction protocol
Photo Giorgio Sancristoforo

Pictures on the next page:
Agarose gel,
Scintillator
with Plutonium 239 source,
ESSOR lab
JRC Ispra site
Photos Valentina Paracchini,
Giorgio Sancristoforo

The Tannhäuser Gate

Giorgio Sancristoforo

I've seen things you people wouldn't believe.
Attack ships on fire off the shoulder of Orion.
I watched C-beams glitter in the dark
near the Tannhäuser Gate. All those moments
will be lost in time, like tears in rain.
Roy Batty, Los Angeles, 2019

As you will walk through *The Tannhäuser Gate* you will change something of me.
You will transform me.
I invite you to do so.

This Gate contains my DNA, the coding regions of my genome.
The Gate uses this data as a programming language for sounds and lights, using quaternary mathematics.
I've called it the "phonosomic" code.

Can you hear me?
I am coded and encoded.
I am flash and spirit,
and now, digital code too.

At the bottom of these pillars there is a microscopic quantity of a sealed radioactive material (Sr-90) shielded with a metal screen. When you will walk through the gate, the screens will rise and rays will hit a Geiger counter, creating a direct interaction with my digitised genetic code.

After some time, radiations will mutate my DNA. It will change my proteins, my enzymes, forming different chains of amino acids, caused by transitions and transversions, deletion and frame shifting of the nucleotides. Different codes will give birth to new sounds, new patterns of lights.

As you will walk through this Gate, you will change something of me.
And maybe your mind will change too.

This is an invitation to transformation.

πάντα ῥεῖ

As I walked along the footpaths that lead to the genomics laboratories, I watched the nuclear power plant on my right, rising majestically among the trees, just above the hill. The high cooling tower had not released steam for many years, the reactor was offline, slumbering in a perennial sleep. The water had been removed, and the nuclear fuel safely stored some hundred meters away from me in a place that perhaps I will never be able to visit. However, I did enter the reactor's building once. Paolo Peerani welcomed me with his distinguishing smile and kindness. There are few opportunities in one's life to see a nuclear reactor up close. Each of us has memorable moments. For me, that moment was one of them.I had passed the security checks with my heart beating faster and faster, one meter after another as I approached the large white building that, for years, I had observed from the other side of the lake. On long summer afternoons, leaning with my feet in the water and listening to the boats passing like swarms of aquatic insects, I had wondered dozens of times what the inside of that colossus must have been like, and now I was about to actually enter it.
In the beginning, I was a little disappointed because I had expected to have to wear a protective suit, gloves and a mask in order to enter the reactor room, just like in the movies, which turned out to be a sign of my ignorance.
They gave me a white coat and we entered through a watertight door like the ones in submarines.
I had seen the ESSOR reactor in the JRC documentaries on the web, filmed while it was still in operation and when men from another era were studying neutrons in that room. I had imagined a great space, but my imagination was not fervent enough. Upon enter-

ing, I noticed that the circular room was immense, like a giant technological pantheon. I could almost hear in my head all the echoing voices of the men that had worked in this mysterious place. Engineers and physicists, brave scientists, of an intelligence and professionalism that I secretly envy and admire.

The reactor was buried under a large and heavy glass cover, in the centre of the room's floor. As I approached it, I struggled to hide my amazement. The core still looked new, as if it had just been built. The metal seemed not to have suffered the ravages of time, yet Paolo told me that much of that metal was transmuted into cobalt 60. Activation, as they call it, happens wherever there are neutron fluxes or proton beams. The material that nuclear reactors and accelerators are made off is transformed over time into other elements. We took a tour of the great circular hall to get a look at what were once the laboratories dedicated to experiments. It was a little sad to see those labs empty and decommissioned. A modern digital Geiger counter on a wall caught my eye. It was marking 18 nSv/h (nano Sievert per hour). I was surprised. I expected to find some radioactivity; instead the value was just a banana[1] higher that the radiation that I could measure at my home. Flying at 35,000 feet for an hour on a normal flight to Rome would give me a dose of radiation 22 times higher than what I was taking in the centre of a decommissioned nuclear reactor room.
Walking along the grassy paths next to the Nuclear Security buildings, I listened to the sound of crisp leaves under my feet. The birds peeped out on the trees with lively songs, the air was fresh and smelled of the countryside. In moments as this, I realised that here, nature had found a balance with science.

I was early, smoking my electronic cigarette trying to pass the time. I had looked at my big folder full of papers and projects of my installation and wondered if people would ever really understand what I was trying to communicate with this artwork. When one talks about radioactivity and genetic mutations, people have only one thing in mind: the horrors of Hiroshima or Chernobyl. But my ambition is to use mutation as a metaphor of change, and radioactivity as a transforming agent. Politics and environmentalism have nothing to do with this work. I am not against nuclear energy, but I am certainly against nuclear weapons. This is not important now. *The Tannhäuser Gate* is a rite of passage, an invitation to a transformation and nothing else…

Sitting in front of the genomics laboratory, I looked at my files and artworks; I had some polaroids: autoradiographs I made with radioactive elements. There were also all the layouts and plans for the construction of the installation, and several graphs of the analysis of the gamma spectra I had made on my own of the radioactive elements that I collected over time. Radioactive materials are fascinating to me and I tried, as far as I could, to study them.
Every time I met Paolo at the JRC, we immersed ourselves in long discussions about how nuclear energy and radioactivity work. I asked a thousand questions and he was never tired of answering. When I discovered beauty in the equations of nuclear reactions, for a moment, I felt like I regretted having become an artist and not a scientist.

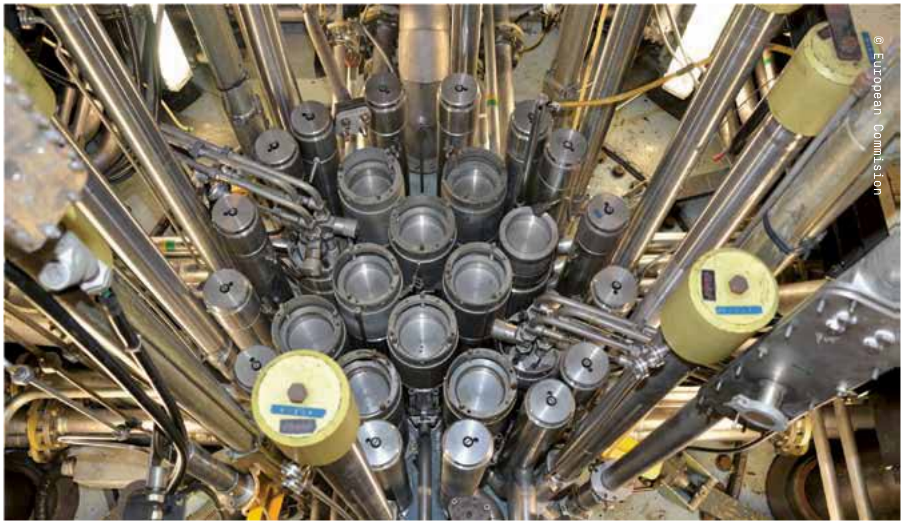
The alchemists of the Renaissance dreamt of the transmutation of the elements; radioactivity, whether natural or artificial, is the realisation of that idea. But just as the gold of the alchemists was actually philosophical gold, radioactivity for me has a symbolic meaning, which goes beyond its scientific explanation. It is the materialisation of change, of becoming. Change is life.
Heraclitus said that “Everything moves and nothing stands still”. When everything in the universe will stand still and no energy will be ever more irradiated, then the thermal death will decree the end of times and the universe that we know will end in a darkness so deep that we cannot even imagine.

My fake cigarette was over, I closed my folder full of hopes and decided to enter the laboratory.
Valentina Paracchini greeted me with a smile. At our first meeting, her colleague, Mauro Petrillo, was also present. I had decided to work with them to explore my DNA. In the beginning, Mauro proposed me to use the DNA of a vegetable, in case I had any fear that my privacy would be violated in some way. I smiled and said that there was no sense in taking DNA from a vegetable. An artist has to “sacrifice” himself a little, and I was happy and eager to know the secrets of my biology, the codes I had inherited from my parents, for better or worse.
I wanted to put myself in the artwork, and if science would ever need my DNA, I'm okay with that. That morning, I had brought two samples of my saliva with me, in two small test tubes. Valentina had given me the tubes a few days before, and now we had to do nothing but extract my DNA. We put on white coats and Valentina took me in the first lab. I was closely watching her work. Various chemical solutions must be used to extract the DNA. All this reminded me somehow of myself when I used to develop films in my dark room. Liquid, bath, liquid, bath… a little shake here and there. The disarming difference was the quantities: micro litres.

Extracting the DNA is a work of extreme patience and precision, with Lilliputian quantities of liquids. Valentina tried to get me to use the pipette, but my hand was shaking. I was afraid of ruining everything. I

Pictures on the previous page:
Radium filled cold cathode tube
Photo Giorgio Sancristoforo

Study materials:
Petchblende specimen,
Thorianite specimen
Photos Giorgio Sancristoforo



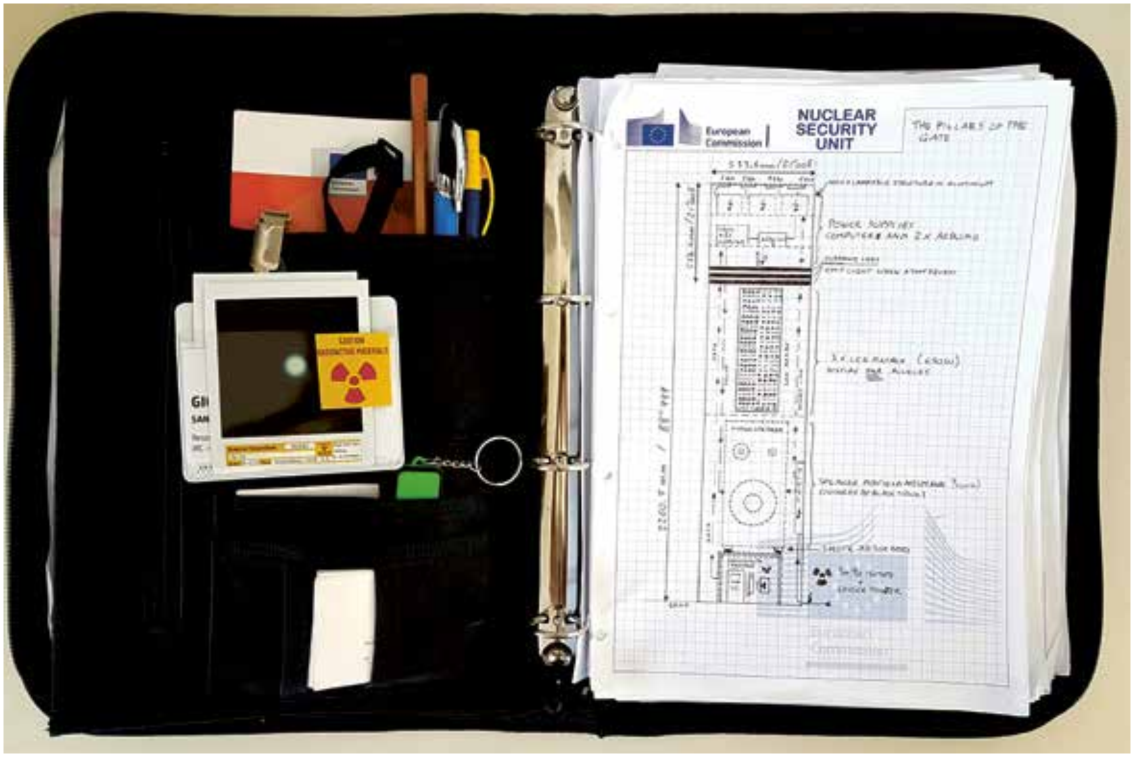
Joint Research Centre
Ispra site
ESSOR Nuclear reactor
Photo JRC Archive

was watching her as she performed dozens of operations that required impressive precision with extreme skill. It was like watching a virtuoso play a musical instrument. We walked through the corridors from one laboratory to another, and once again I was asking endless questions. I wanted to see every tool, every step, every protocol, trying to understand to the best of my ability what I was observing.
Millions of people today can get DNA analysis done, but how many can attend the process?
I asked Valentina to write a report by hand with a pen, as they used to do once, before computers became typewriters. This amused her. I wanted everything to be included in the artwork materials. When we finally put the agarose gel with the samples of my DNA under the UV light, we checked the quality of the extraction. She was very satisfied and I had a big smile on my face.

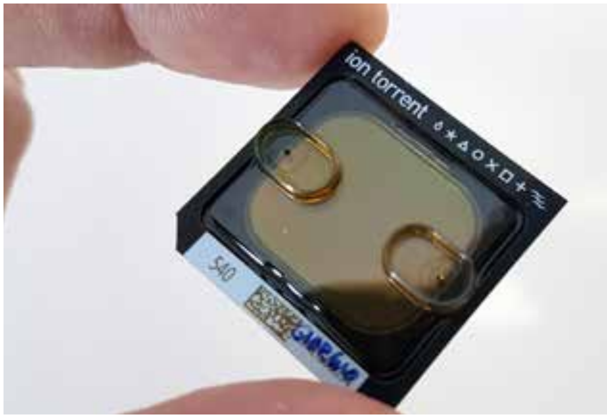
What did I want from my DNA? What part of it? There were many questions, and I had asked Mauro to recommend a book on Genomics to me. This was added to the radio-protection and nuclear physics books I already had on my desk, which I was reading and studying avidly every night. It was an opportunity for me to become passionately interested in biology. DNA is fascinating in many aspects and genomics opened up a new world for me.
Arthur Lesk wrote that DNA is like a music score. The musicians follow the score, interpreting it. Yet, as I am a musician myself, this metaphor did not satisfy me entirely.
Our DNA does not define us completely. Our history, our experiences, the environment in which we live in, and the epigenetic factors, all contribute in a fundamental way.
One day in the laboratories of the JRC, I looked at Mauro, who is a biologist expert in bioinformatics and I told him: “The DNA is an operating system”.
He smiled and nodded, “Exactly!”

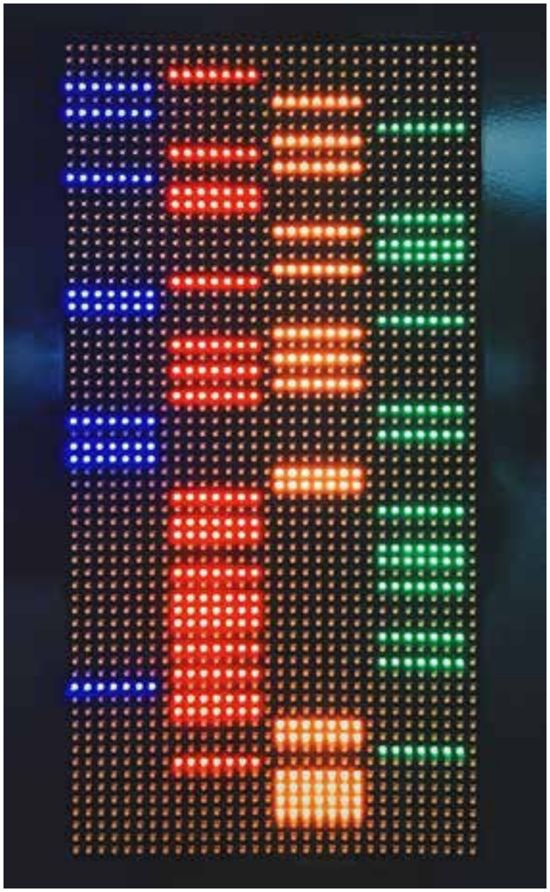
There is something extremely bewildering in this. I’m obviously not talking about intelligent design, but about evolution.
First of all, computers and all digital devices have error correction codes. Errors are inevitable in a transmission, we cannot avoid them, but we can fix them. For example, a hard disk has an error-finding system called Cyclic Redundancy Code. The DNA has several error correction methods. The double helix with the two strands is already in itself an error correction system. Then in the DNA replication there are enzymes that

control and correct the code. If this is not enough, we must reflect for a second on the words “genetic code”. Human DNA is composed of about 3 billion nucleobases. Of this very long molecule, only 1.3% encode proteins and enzymes. This part of the human genome is precisely what we call the genetic code. The code is composed of a sequence of blocks of three bases called codons or triplets.
As in software, the first codon is a start header, then a variable number of codons follow, and finally the code always ends with one of three possible stop codons. In other words, the genetic code behaves in a way very similar to machine language instructions. Naturally, humans invented machine language long before the discovery of genetic code. This suggested to me once again, that nature steers evolution by choosing the most efficient of solutions. Humans, in creating computers, have done nothing but the same: choosing the most efficient method.
There is only one big difference between nature and men: “Nature never wastes anything, not even its errors.” as Mauro told me once, with a touch of Neapolitan philosophy that reminded me of Luciano De Crescenzo.
When I understood the basics of the genome with its introns, exons and the mitochondrial DNA, it was clear to me that the DNA I wanted to get sequenced from my saliva was the coding DNA. Codes are fascinating. We live immersed in codes. Our language, our music and even our art.
I write code almost every day.
The fact that even I am myself composed of codes makes me feel at ease.
The atomic era and modern research efforts on can-



The Tannhäuser Gate,
Resonances III Datami
Giorgio Sancristoforo,
construction plans, 2019





cer have generated in the public opinion, the perception that genetic mutation is always necessarily bad. Undoubtedly, many mutations are of a negative nature. Nevertheless, it must be considered that if it were not for genetic mutations, we would still be small fish in the ocean, and not human beings.
The entire evolution of the species is based on the chances of a mutation in the genetic code. These mutations have multiple origins. Environmental factors and chemical substances of various kinds can modify DNA (in the era in which we live, tobacco and alcohol are among the most common mutagens), some viruses can transfer their DNA into an organism and finally, ionising radiations can alter the genetic code.
These are induced mutations. Other mutations are spontaneous: sometimes proteins can explore new combinations of amino acids, sometimes the DNA changes due to a simple replication error.
One day in the remote past of the Earth, a giraffe was born with the neck longer than the others. This gifted giraffe found more food on the highest peaks of the trees, then it mated and other giraffes with long necks were born. After many generations, giraffes with long necks had the upper hand over the others, showing that not all mutations come to harm.

I left the lab after a whole afternoon dedicated to extracting my DNA. In the following weeks, Valentina would sequence the DNA, and then, Mauro would analyse and assemble the data with the supercomputers at the JRC Data Centre.

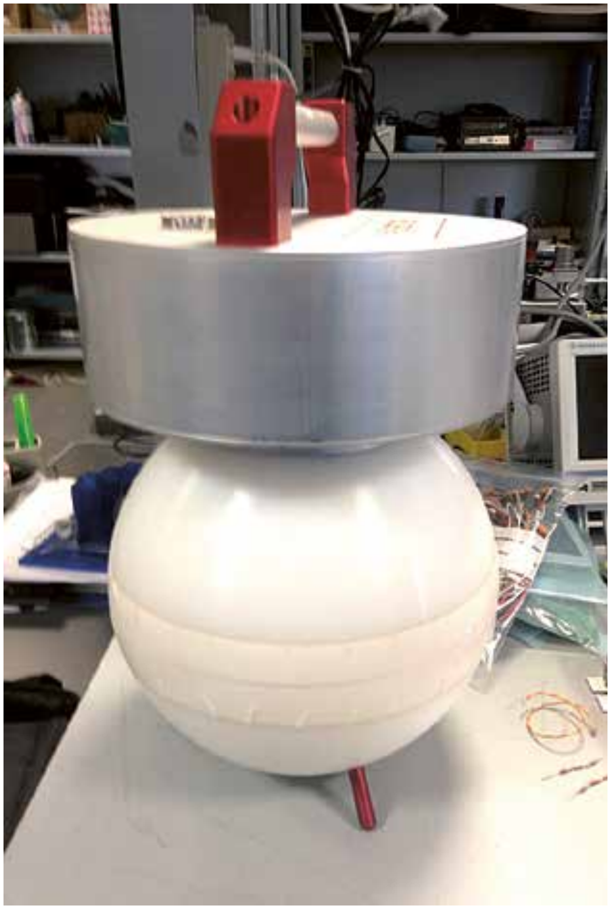
A sunny day of March, I arrived at the JRC security check with my professional Geiger counter. In my life, I have owned dozens and dozens of musical instruments, but no instrument has ever given me the satisfaction I feel when I use this measuring instrument.
Antonio Migneco from Nuclear Security had promised me a visit to the laboratory where they test, repair and calibrate the Geiger counters and radiation detection portals. Paolo was there waiting for me.
A large poster with the isotopes' chart hung on a wall over a desk with many monitors and in the centre of the lab, there was a large table filled with measuring and repairing instruments.

Pictures on the previous page:
DNA-sequencing-chip
Photo Giorgio Sancristoforo

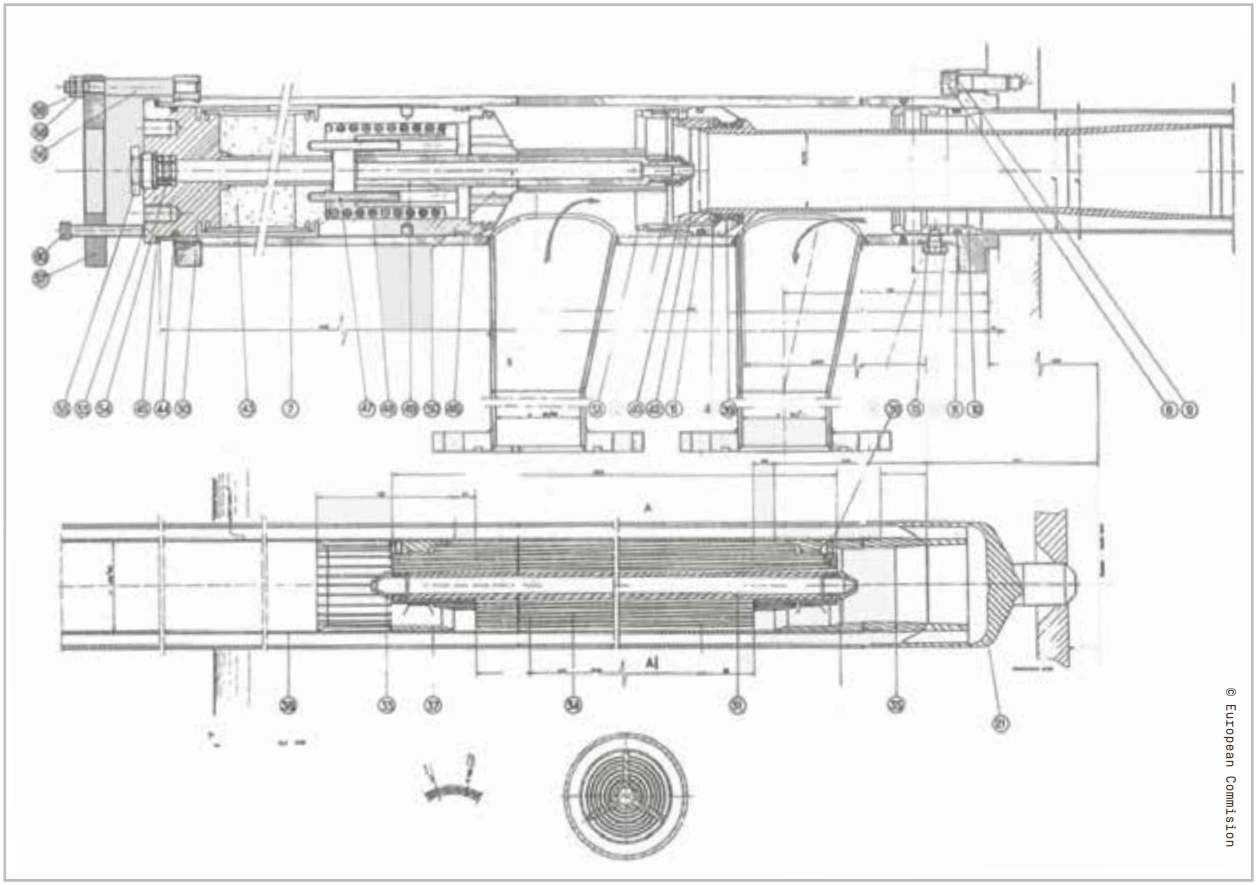
The Tannhäuser Gate
Resonances III Datami
Installation view, [detail]
Photo Andrea Cerrato

Study radioactive materials.
Common objects: camera lens, smoke detector ion chamber, keychain tritium vials, uranium glass.
Artificial sources: Barium-133, Cobalt-60, Caesium-137, Europium-152, Strontium-90.
Photos Giorgio Sancristoforo

I proudly showed my Geiger counter, costing more than a Minimoog[2].
"Let's do some measurements", proposed Antonio. I nodded, smiling.
Antonio took some items from clear plastic bags: watches, cold cathode tubes, a thorium gas mantle, some welding rods. I took measurements with my Geiger counter and compared the values with the same radioactive objects in my collection."This is the tourists' set", I said laughing. Antonio and Paolo laughed too. "Okay then, let's look at something more special. Do you have any requests?" Antonio said.
They could not have asked me a more welcome question. Without hesitation I said "Plutonium!". Without raising an eyebrow, Antonio took a test disk similar to the ones I own for gamma spectroscopy from a metal safe at the end of the room. The black disk had a tiny centre of greyish metal, very similar to lead.
Few people in the world can see plutonium with their eyes. My excitement was comparable to the first time I went to hear Stravinsky's Rite of Spring. He put the little disk under a scintillator with its crystal covered with a thin sheet of mylar and then turned on an oscilloscope. We compared the reading with a disk of caesium 137 like the ones I use for my autoradiographs. The plutonium peak was much stronger.
The explanation was simple: while caesium emits beta rays (electrons) and gamma rays (photons), plutonium decays with alpha particles (helium nuclei). The kinetic energy of the alpha particle is much higher.
With Paolo, we decided to use Strontium 90 for the installation. Beta rays are easier to handle, we can block them with aluminium. People will therefore not be irradiated by my artwork!
Then, I looked at the big detectors for contamination. They were so sensitive that they could detect the radiation emitted by a simple tuff brick. A large neutron detector was also resting on the table. Paolo explained to me how they work.
"If I ever build a small Fusor[3] one day, I'll need one of these", I said. Antonio looked at me with amazement and an incredulous smile. "What do you want to do with a small fusion reactor?" Antonio asked. I hesitated a moment, because I was afraid of looking too frivolous or crazy. "I would like to make people listen to the sound of a small artificial star". Antonio and Paolo smiled once again. "The only big problem is finding deuterium gas", I added. It's not something you can buy on Amazon". Paolo nodded. But it didn't take me long, in the following weeks, to realise that maybe I could get some deuterium from heavy water with electrolysis. That is not difficult to find, I thought. Certainly, it's not a joke: turbo-molecular pumps and voltages can kill a man in the blink of an eye. I left the workshop completely happy and put aside for a while my dream of an installation on the song of a small star.



Neutron detector, ESSOR Lab
JRC Ispra site
Photo Giorgio Sancristoforo

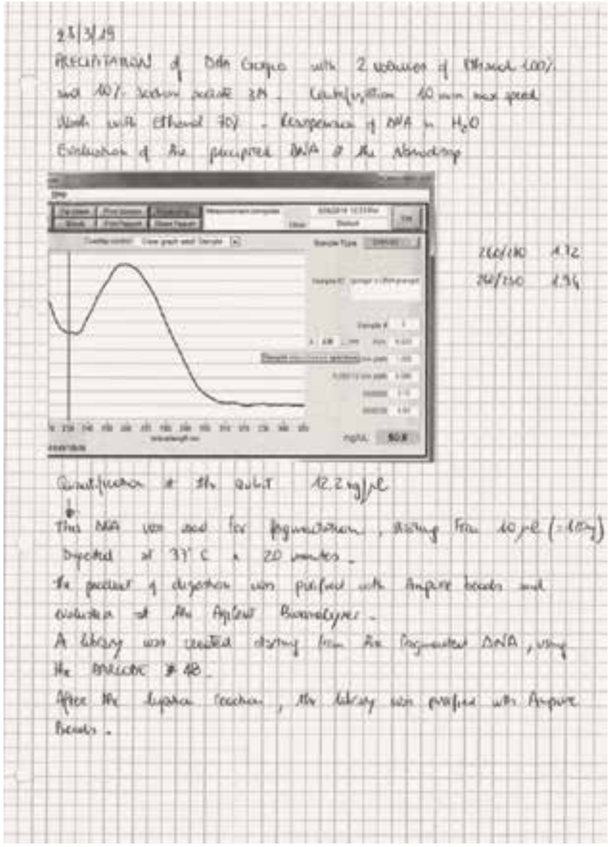


The JRC ESSOR
Nuclear Reactor fuel rods
construction schematics
JRC Archive

Now I had to concentrate on *The Tannhäuser Gate*.

Back home from the JRC, one day I received an email from Mauro. After three days of painstaking calculations at the Data Centre, my DNA was finally assembled and the CDS (coding regions) of all my chromosomes were extracted. Mauro put all the data in long text files in a zip archive. Every CDS was diligently filed under their respective chromosome. I was ecstatic. Mauro did a wonderful job, indulging in all my requests.
It was strange for me to receive a sort of digital copy of myself by mail.
Even stranger was the feeling I felt after backing up the file in three different hard drives. For years I didn't want children and now I had multiple copies of myself in my computers. Of course, I knew that those were not really "copies" of myself, but that alienating feeling remained for a while, until I got used to thinking that somehow, I was now digitised. I did it before any corporation or government got there first. Who knows what the future will be, and if DNA will play a great part in security as well as in commerce.
My Big Data was in my own hands, I could start exploring myself in a whole new way. This, for the first time, made me feel like a man of the 21st century. After all, the Internet was born in the previous century. I

13/03/2019
SALIVA sample was collected in ORAGENE 600 tube (in the morning, before eating)
2 TUBES = 4 ml each
The solution of saliva and stabilizing reagent was incubated at 50°C = 1h
Then the DNA was extracted from 1 tube starting from 2 ml
PROCEDURE
1. Centrifuge the mix of saliva and stabilizing reagent for 10 min at max speed in a microcentrifuge
2. Remove the supernatant
3. Loosen the pellet by flicking the tube
4. Add 1 ml PBS. Dissolve the pellet by vortexing
5. Centrifuge for 5 min at 1800 x g. Remove the supernatant. Resuspend the pellet in 180 μl PBS
6. Add 25 μl QIAGEN Proteinase K and 200 μl buffer AL. Mix and vortex. Incubate at 56°C = 10 min
7. Add 200 μl Ethanol 100%. Mix by vortexing
8. Transfer the sample into a QIAamp Mini spin column. Centrifuge 1 min at 8000 rpm. Discard the flow-through
9. Place the column in a new collection tube and add 500 μl Buffer AW1. Centrifuge 1 min at 8000 rpm. Discard the flow-through
10. Place the column in a new collection tube and add 500 μl buffer AW2. Centrifuge 3 min at max speed. Discard the flow-through
11. Place the column in a new tube. Add 100 μl H_2O. Incubate 1 min at room temperature and centrifuge 1 min 8000 rpm to elute DNA



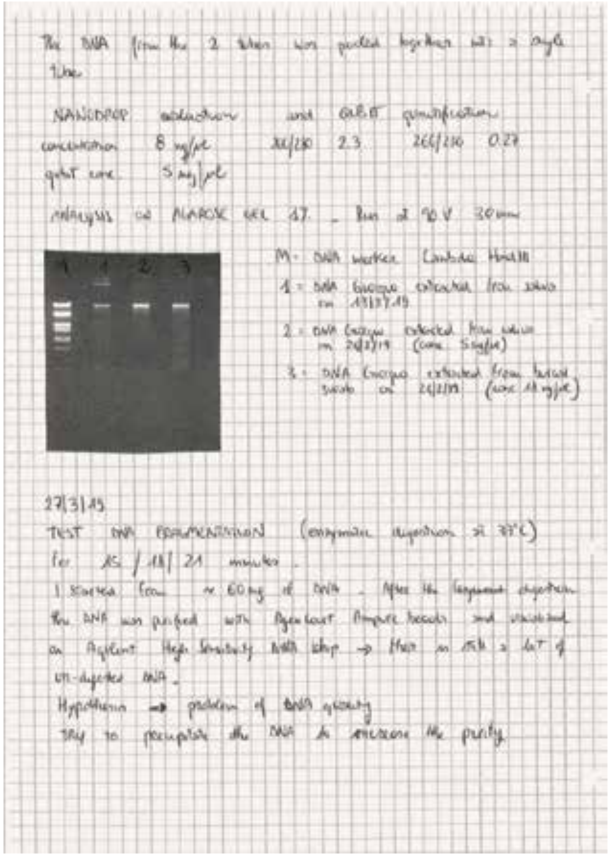
23/3/19
PRECIPITATION of DNA Genome with 2 volumes of Ethanol 100% and 10% sodium acetate 3M. Centrifugation 10 min max speed
Wash with Ethanol 70%. Resuspension of DNA in H_2O
Evaluation of the precipitated DNA at the Nanodrop

260/280 1.72
260/230 1.94

Quantification at the QUBIT 12.2 ng/μl
This DNA was used for fragmentation, starting from 10 μl (=100 ng)
Digested at 37°C = 20 minutes.
The product of digestion was purified with Ampure beads and evaluated at the Agilent Bioanalyzer.
A library was created starting from the fragmented DNA, using the BARCODE # 48.
After the ligation reaction, the library was purified with Ampure Beads.

The Tannhäuser Gate,
Resonances III Datami
Valentina Paracchini,
Notes of laboratory work, 2019

was chatting already in 1986 with a C64… The real game changer of our era is the genetic code at hand. Probably one day we will all be digitised, and the difference between the biological and the artificial will become thinner and thinner in the next centuries, until it will disappear.
Now that I had my code, I could transform it. After all this was my goal, hacking myself.
Hacking my DNA. But what does "my DNA" really mean? The DNA of a human being is for the most part the same for everyone. Only the ~0.1% of my genome has differences with the genome of any other inhabitant of this planet. That ~0.1% are the polymorphisms that make us biologically "different" from each other. From eye colour to shape of lips, from the predisposition to certain diseases to a dairy intolerance. If my intention was to put my DNA in The Tannhäuser Gate, I had to find those polymorphisms. Valentina had taught me how to use the BlastN suite. Anyone studying genomics must use this tool sooner or later. It allows the user to insert any DNA sequence and to predict its similarity with a "standard" DNA. Not only could I see if a given sequence had variations, but I could, at least superficially, understand which protein was encoded by that piece of code, what function it had and whether or not it was associated with some kind of disease. Human DNA is like a continent, with de-

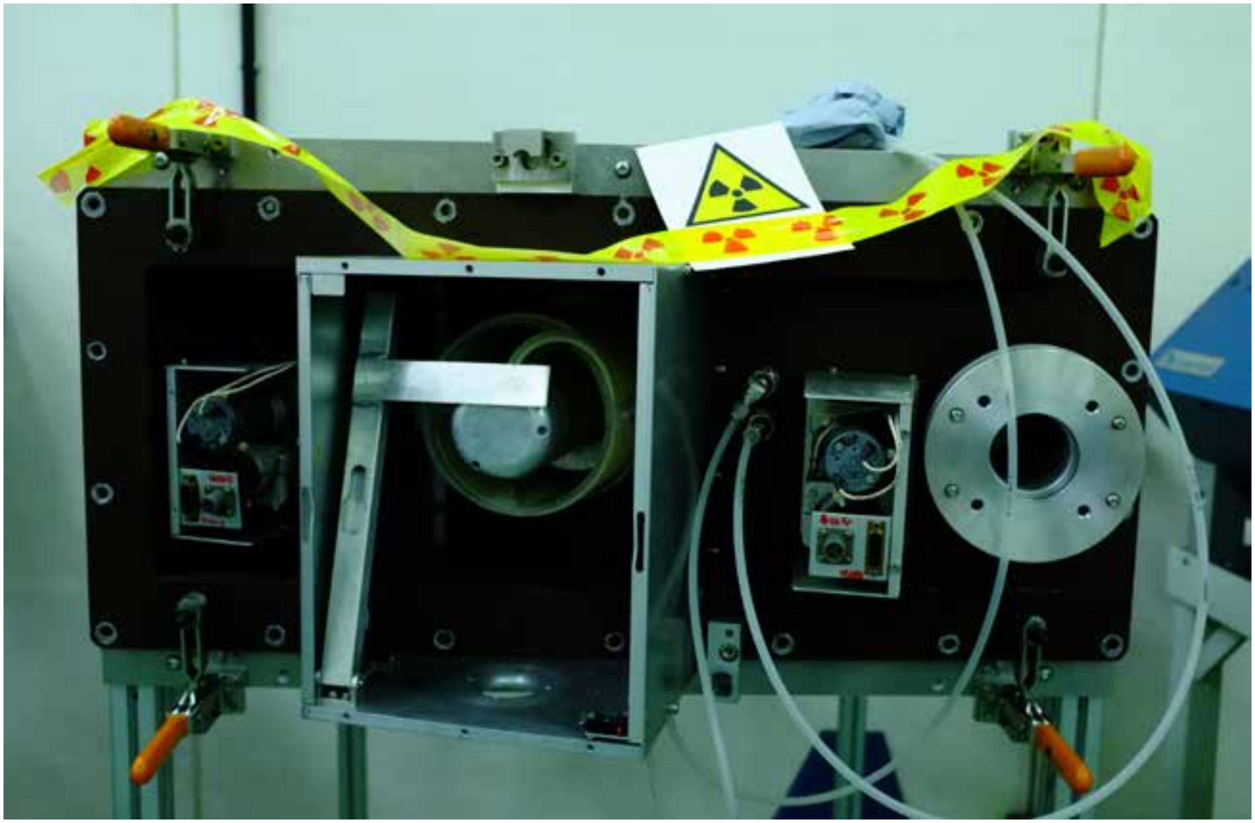


The Tannhäuser Gate,
Resonances III Datami
Valentina Paracchini,
Notes of laboratory work, 2019

serted areas and overpopulated zones full of activity. Exploring it causes a vertigo that is nowhere near comparable to any other session of surfing at the computer. No Google Maps or star atlas can be compared to a glance into the depths of our “operating system”.

The weeks followed one after another while I was programming the computer to make my DNA sounds. The military Geiger counter on my desk ticked nervously as I brought my thorum coated Pentax lens closer to the probe. The LED displays began to illuminate the room with beautiful colours. I lit my fake cigarette and closed my eyes. The sound was changing and the colours with it. My digitised DNA was starting to mutate. For a moment, I wondered what a horrible transformation that mutation would bring about in the real world. But then, I suddenly thought that perhaps, I had just given myself the ability to perceive magnetic fields or to smell the scent of a lavender field hundreds of miles far away.

After all, art must dare.

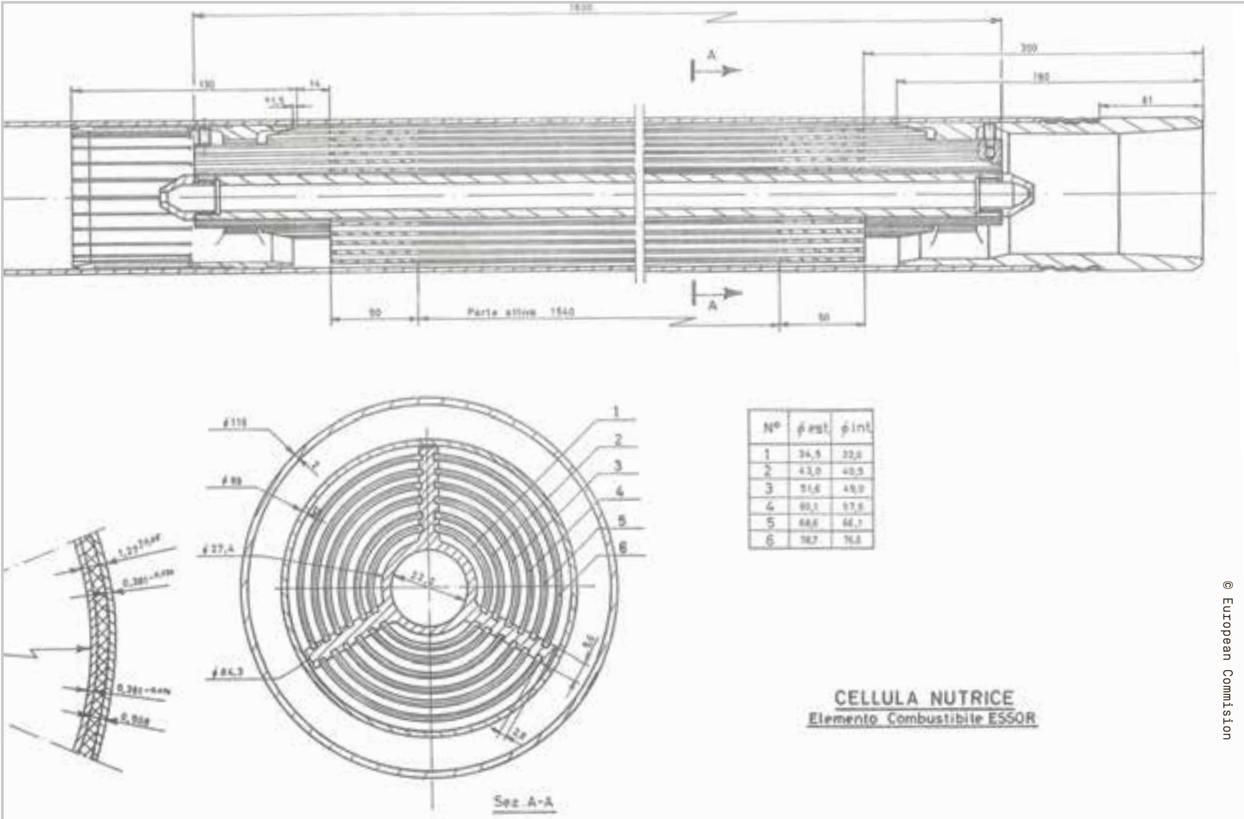


Decommissioning of JRC's
Cyclotron equipment
JRC Ispra site
Photo Giorgio Sancristoforo

Technical and Scientific Appendix

What I love about electronic music, is its intimate connection with science. Pioneers such as Karlheinz Stockhausen and Herbert Eimert invented sound synthesis using scientific instrumentation, trigonometry, information theories, and the help of the physicist Werner Meyer Eppler. My love for electronic musical instruments was a romance that vanished when I discovered computer music and programming languages. With programming and mathematics one can translate almost anything into sound, create entire new worlds of sound. NASA had demonstrated this many years ago with the data on the electromagnetic fields of planets, collected from Voyager probes.

The reason why I became interested in radioactivity for the first time has to do with random numbers. Computers really are not able to generate true random numbers.
These numbers in a computer are the product of a formula: a very long string of pseudo-causal numbers that repeats itself after a long time. To generate true random numbers, one needs a physical random source. There are various methods for deriving such numbers, and there are many good reasons in music for using random numbers.
I've always been interested in electronic music that



The JRC ESSOR
Nuclear Reactor fuel rods
construction schematics
JRC Archive

isn't deterministic, I like to be amazed by the machine, by the robot that sings. Algorithmic music, after all, is always composition, but at a different level. It is like composing a seed that will develop by itself, each time a little different.

Radioactive decay is a true stochastic phenomenon. We cannot predict when an atom will decay, and at the same time it is not a totally chaotic phenomenon, it has patterns. And the patterns are interesting. At the beginning of my radioactive experiences I simply used the Geiger counters and weak radioactive sources to produce irregular tempos. Randomly triggered sound events.Then, over time, I became interested in more sophisticated instruments capable of discriminating the energies of radioactive decays: gamma spectroscopes. Each radioactive element has its own energy signature. It emits radiation at certain energy levels that make it possible to recognise the isotope from the energies themselves.So, one day I brought my gamma spectroscopy to the JRC and in front of an audience of scientists I made them hear the sounds derived from the decay of Thorium 232 and Cesium 137.
I confess: I had cold sweats.

Phonosomes

At that time, I had already devised a way to create sounds from the DNA. The idea came to my mind on a July morning after I made the JRC summer school on Big Data, which was the premise to my residence.

As often happens to me, I got up too early that morning, made a cup of coffee and turned on the computer. The DNA is a very long molecule composed of four nitrogenous bases: adenine, thymine, cytosine and guanine repeated in different sequences more than three billion times. We can therefore imagine the genetic code as a series of sequences of four letters: A C G T permuted in all possible combinations in groups of three nucleobases that form amino acids, and then polypeptides chains. Sound is basically mathematics, and to transform DNA into sounds, I had to find a way to get numbers instead of letters.

We give the letters an arbitrary numerical value (which will be justified later). We assign to thymine the 0, to the cytosine 1, to the adenine 2 and to the guanine 3. Computers function with a code called binary, made of only 0s and 1s. The DNA instead can be imagined as a quaternary code. Using the same logic as the binary code, we get a positional notation with a radix of 4. For example, the ATG codon in quaternary mathematics is the number 203. Remember, this is a positional notation, so the first digit on the left is multiplied by 16, the second by 4 and the last by 1. The result in decimal is 35 (32 + 0 + 3). The codons of the genetic code are 64, that is all the permutations of a triplet composed of four possible numbers.

Now the careful reader might ask me why use a quaternary system when the combinations of possible triplets are 64. Why not use the numbers from 0 to 63 directly? The answer is a question of efficiency.
It is linked to the fact that I intend to simulate the mutation of the genetic code using radioactivity.
The CDS files of my genome that Mauro assembled from the data sequenced by Valentina, are long strings of letters like:
<AGCGCTTTCACCATTACGAGACTGAC...
If I used only 64 numbers, I would have to continually compare groups of three numbers to a database, both in the first reading and during the mutation. And, the mutation process would be overcomplicated. Using my quaternary code instead, I can make the dec-

The JRC Cyclotron Control Room
JRC Ispra site
Photo Giorgio Sancristoforo

imal conversion only once, at the end, whether there is, or not, a mutation.

How is the sound produced in the Gate?
Every column loads a CDS file and creates the sound using blocks of 60 nucleobases plus the 60 of the complementary strand. These 120 bases are organised in ten groups of four triplets. This has been done to maintain a certain analogy with the mRNA, which is used to synthesize the proteins. Nine groups of four triplets generate a sound through a form of digital synthesis of sound called frequency modulation. A sound mRNA we could say…
The first triplet in the group encodes the frequency of the carrier oscillator, the second its amplitude, the third the modulation index and the fourth the frequency of the modulating oscillator, according to this simplified equation:

$$FM(t) = A_c sin(\omega_c t + A_m sin(\omega_m t))$$

Where ωct is defined by the first triplet of the group, Ac by the second, Am by the third and ωmt by the fourth. (in the complementary strand, this order is reversed). For the oscillators' frequencies, I used a known equation that translates a MIDI note in Hertz:

$$f_m = 2^{(m-69)/12} * 440Hz$$

Where fm is the frequency in Hertz and m is the MIDI note with the reference tuning 69 = 440Hz. Because we have 64 possible notes over a full MIDI range of 0-127 notes, an offset is added to transpose the frequencies to the desired octave. For the amplitudes of the amplifiers, a proportion was made by dividing the numbers by 64 and thus obtaining values between 0 and 1 where 1 = 0 dBFS and 0 = -96 dBFS. The tenth group has an effect on the sound of all the generators and decides the envelope and duration of the sound. So in summary, each pillar generates nine independent synthesised sounds programmed from my DNA, which is mutated by actual radiations.

Then what triggers sounds? The radiation itself. The Geiger counter and the radioactive element not only mutate the sequences of the genetic code, but also act as “pick” of the instrument, stimulating the production of sounds.

Mutations

In The Tannhäuser Gate, we only consider the direct effects of radiation on DNA. We will not therefore consider the indirect effects, i.e. the creation of free radicals that can bring the cell to apoptosis or cell death. What I'm interested in showing, is the induced mutations by radiations.
For this installation, we have opted with Paolo to use two Strontium 90 sources for security reasons. This isotope is practically a pure Beta ray emitter, and the radiation can be easily blocked by the aluminium structure of the pillars. Therefore, everybody can rest assured that the public will never be exposed to any form of ionising radiation.

Beta rays are electrons, which have a minuscule mass compared to that of an alpha particle and a much lower penetration into matter than gamma rays. When a beta ray interacts directly with the DNA molecule, it tears away the electrons from the atoms it encounters. Now DNA has some weak points in its structure, in particular the hydrogen bonds between the two strands, and more in general in any covalent bond.
In our body, DNA is subject to continuous repairs. It is estimated that due to environmental factors and metabolic processes inside the cells, DNA damage occurs at a rate of 10.000 to 1.000.000 molecular lesions per cell per day. However, when the damages are too numerous, then the probability of errors during the repair or replication of the DNA rises dramatically, causing induced mutations.

Basically, we can have four types of mutations in the genetic code:

1) Transitions: interchange between two purines (A<->G) or two pyrimidines (T<->C).

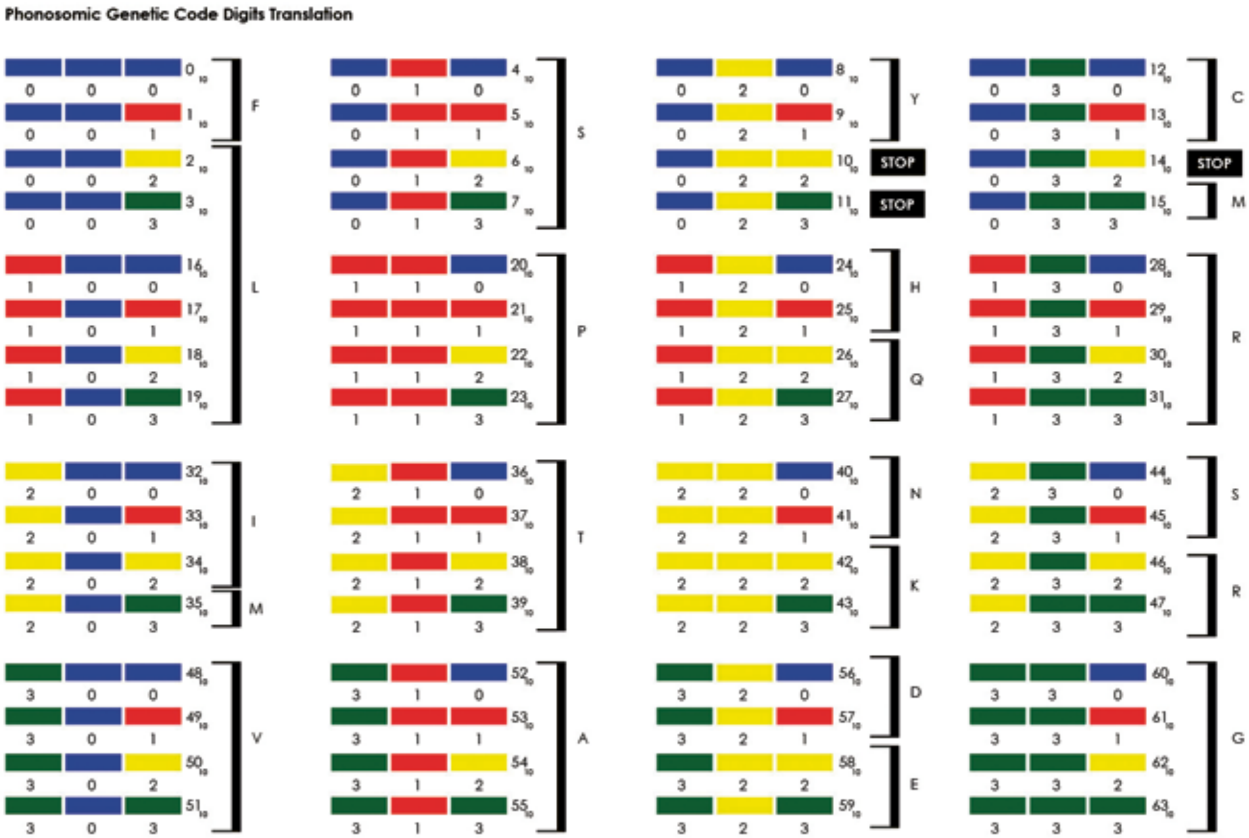
The JRC Cyclotron [detail]
JRC Ispra site
Photo Giorgio Sancristoforo

2) Transversions: interchange between purines and pyrimidines.
3) Deletions: one or more bases are deleted.
4) Insertions: one or more bases are added.

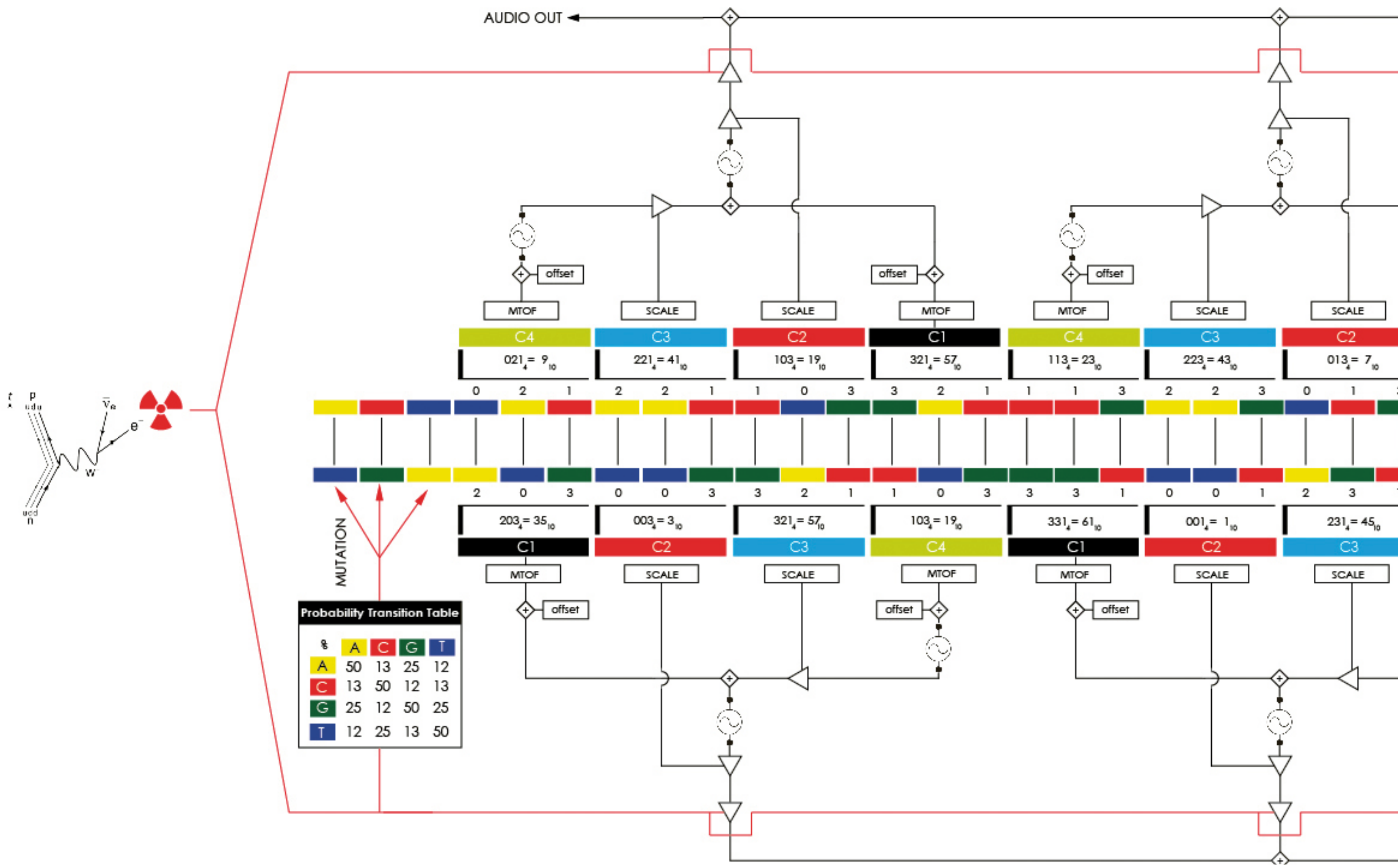
Transitions have a greater chance than transversions to happen, so I had to create a probability table to handle these mutations. This system is of course a reduction of reality because many other effects should be taken into account, such as “wobbles”.

Nevertheless, it is accurate enough to be a satisfying simulation for an artwork.

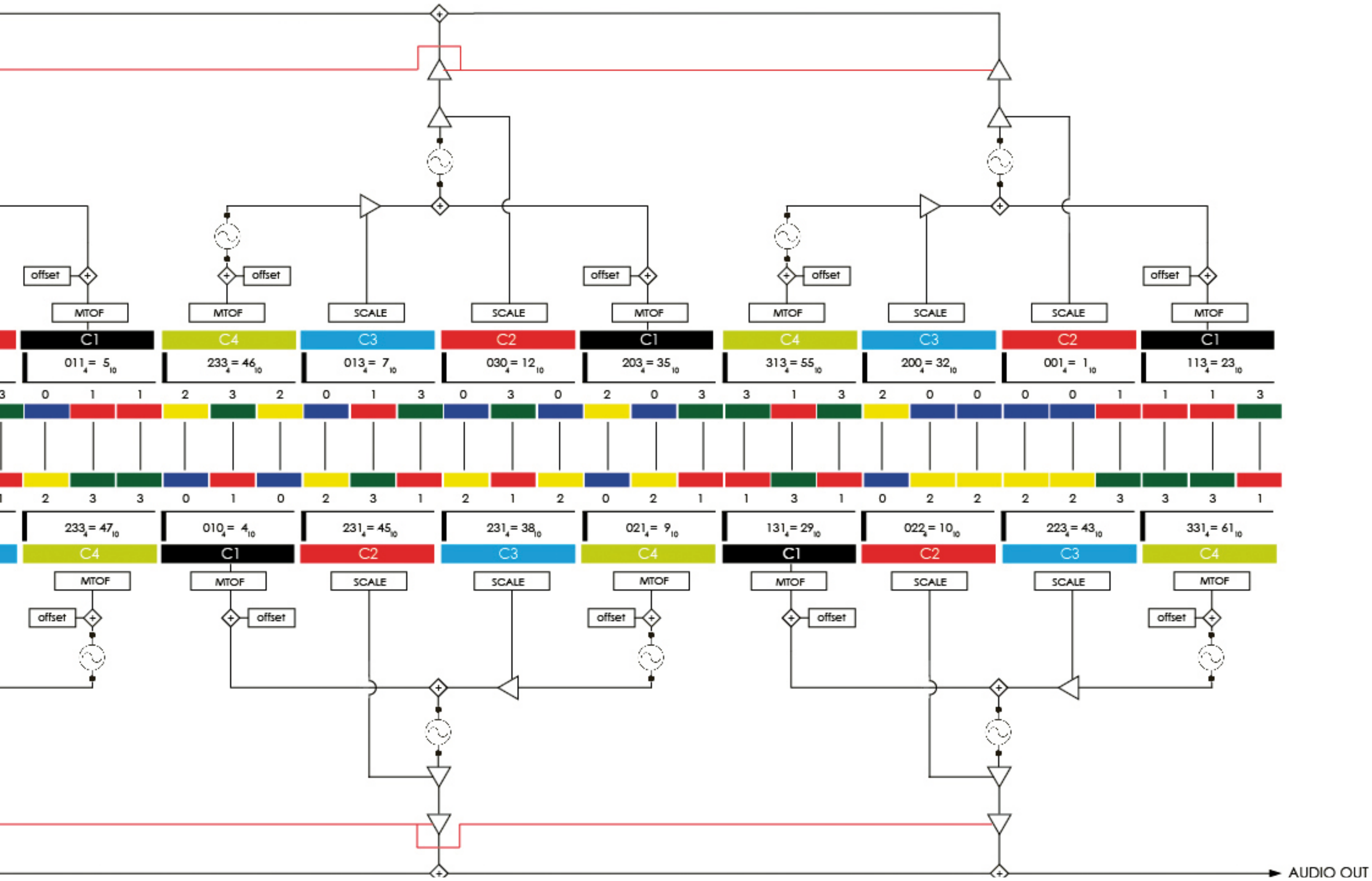
1 Banana equivalent dose [BED] is an informal measurement of ionizing radiation exposure, intended as a general educational example to compare a dose of radioactivity to the dose one is exposed to by eating one average-sized banana. Bananas contain naturally occurring radioactive isotopes, particularly potassium-40 [K-40], one of several naturally-occurring isotopes of potassium. One BED is often correlated to 0.1μSv
2 The Minimoog is the most famous musical synthesiser, invented in the early 1970s by Dr. Robert Moog
3 A Farnsworth-Hirsch inertial electrostatic confinement device, a common fusion reactor among amateurs.



The Tannhäuser Gate,
Resonances III Datami
Giorgio Sancristoforo, Phonosomes:
Quaternary Digits translation of
the genetic code, 2019



The Tannhäuser Gate,
Resonances III Datami
Giorgio Sancristoforo
Phonosomes algorythm, 2019


offset
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C3
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AUDIO OUT

Weather Prediction by Numerical Process - a Forecast for Europe

Artists
Joshua Portway
Lise Autogena

Scientist
Jutta Thielen-del Pozo

Collaborators
Florian Pappenberger, ECMWF
Peter Lynch, University College Dublin
Leonard A. Smith, University of Oxford

Supporters
European Centre For Medium Range Weather Forecasts
Sheffield Hallam University

Weather Prediction By Numerical Process
- a Forecast for Europe,
SciArt Datami project, 2019
Performance installation, stamps, card, ink

Weather Prediction by Numerical Process - a Forecast for Europe, Resonances III Datami Festival JRC Ispra site 15 October-8 November 2019 Installation view during the performance Photo Lise Autogena & Joshua Portway

Weather Prediction by Numerical Process - a Forecast for Europe

Lise Autogena & Joshua Portway

Project description

Weather Prediction by Numerical Process - a Forecast for Europe is a performance in which the weather is forecast through human labour, thus turning the act of calculating the computation into a social action. It is a tribute to the heroic effort of Lewis Fry Richardson, a pacifist Quaker who spent his time as a medic during World War I calculating the first numerical weather forecast by hand. Working before the days of electronic computers, he had the utopian dream that the nations of the world would come together to create a vast "human computer", a Forecast Factory consisting of many thousands of "calculators" who would work around the clock to calculate the weather for the good of all humankind.

In a post-climate-change world in need of explanatory myths and rituals, Richardson's epic calculation deserves to be mythologised as one of the founding moments of a new science and re-contextualised in the context of today's anxieties about climate change and social fragmentation. For this performance installation, the artists translated Fry Richardson's original worksheets into a written formulae; a step-by-step algorithm of physical instructions for performing a weather forecast for Europe. The direct encounter with the actual material of "big data" simultaneously emphasises the vertigo inducing scale of modern data processing and temporarily creates a more human relationship to something usually experienced as cold and inscrutable.

The performance installation is the first part of a larger work to produce a large-scale participatory performance of Lewis Fry Richardson's original vision of a Forecast Factory.

Background

Weather Prediction by Numerical Process is a tribute to a defining moment in the history of climate and weather forecasting. Between 1916 and 1919 Lewis Fry Richardson produced the first modern weather forecast. As a Quaker and pacifist, he worked as a medic during the First World War while using any spare time he could find to work on his idea to forecast the weather mathematically.

His forecast was very primitive compared to today's calculations, although it required hundreds of thousands of individual computations. Since electronic computers didn't exist, he had to do every single calculation by hand, methodically working day after day on this massive task, while trying to survive the horror of the trenches. Today's weather and climate science has been built upon this single feat of perseverance.

When Richardson returned from the war and verified his work, he realised that he had made a fundamental mistake, which meant that his calculations produced very unrealistic results. Nonetheless, he was

Lewis Fry Richardson, Eskdalemuir observatory, 21 June 1913 convinced that his technique was viable and that it could be used to produce a realistic forecast, but he also realised the monumental human effort that would be required to achieve this task. A real-time global weather forecast, in the days before electronic computers, would have been a mammoth undertaking on the scale of the moon landings or the Manhattan Project - Richardson estimated it would require 64 000 “human computers” working around the clock. But in his utopian vision, the tremendous benefits of such a massive global collaboration would have made it worthwhile.

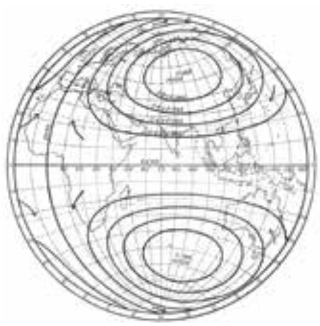
The Performance

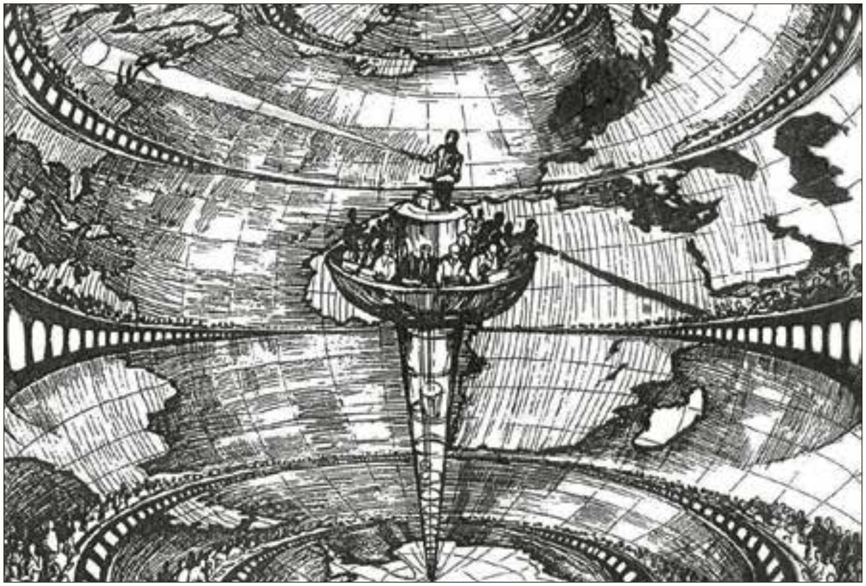
The development of *Weather Prediction By Numerical Process* involved the translation of Lewis Fry Richardson’s original worksheets into a written formulae, a step-by-step algorithm to enable “human computers” to perform the weather forecast by hand.

The performance of the weather forecast took place at a work desk scattered with index cards, pens, and rubber stamps. The rubber stamps are used to stamp the cards with calculation forms that describe the process of the calculations: A blank index card is rubber stamped to create a form, then some of the fields on the form are filled in using other rubber stamps, after which numbers are copied into the form from other index cards. The (human) computer works through the form step by step, performing the calculations specified. At the end of the calculation the card is pinned to a grid on the wall - the specific location specified by rubber stamped numbers on the card. Each card takes approximately five minutes to complete.

Over time, the grid on the wall fills up with completed calculations - once the grid is full, a new set of blank index cards is used and a new grid (a new iteration of the calculation) is started. The grids represent a map of Europe, with each card in the grid containing the atmospheric data (wind speed or pressure) for that position on the map. Each grid represents the state of the weather 45 minutes after the previous grid.

The performances of *Weather Prediction by Numerical Process - A Forecast for Europe* took place at the European Commission’s Joint Research Centre (October 2019), BOZAR in Brussels (December 2019) and GLUON in Belgium (February 2020). The date chosen for the weather predictions was the 29th October 2019 (at that moment still expected to be Brexit Day).

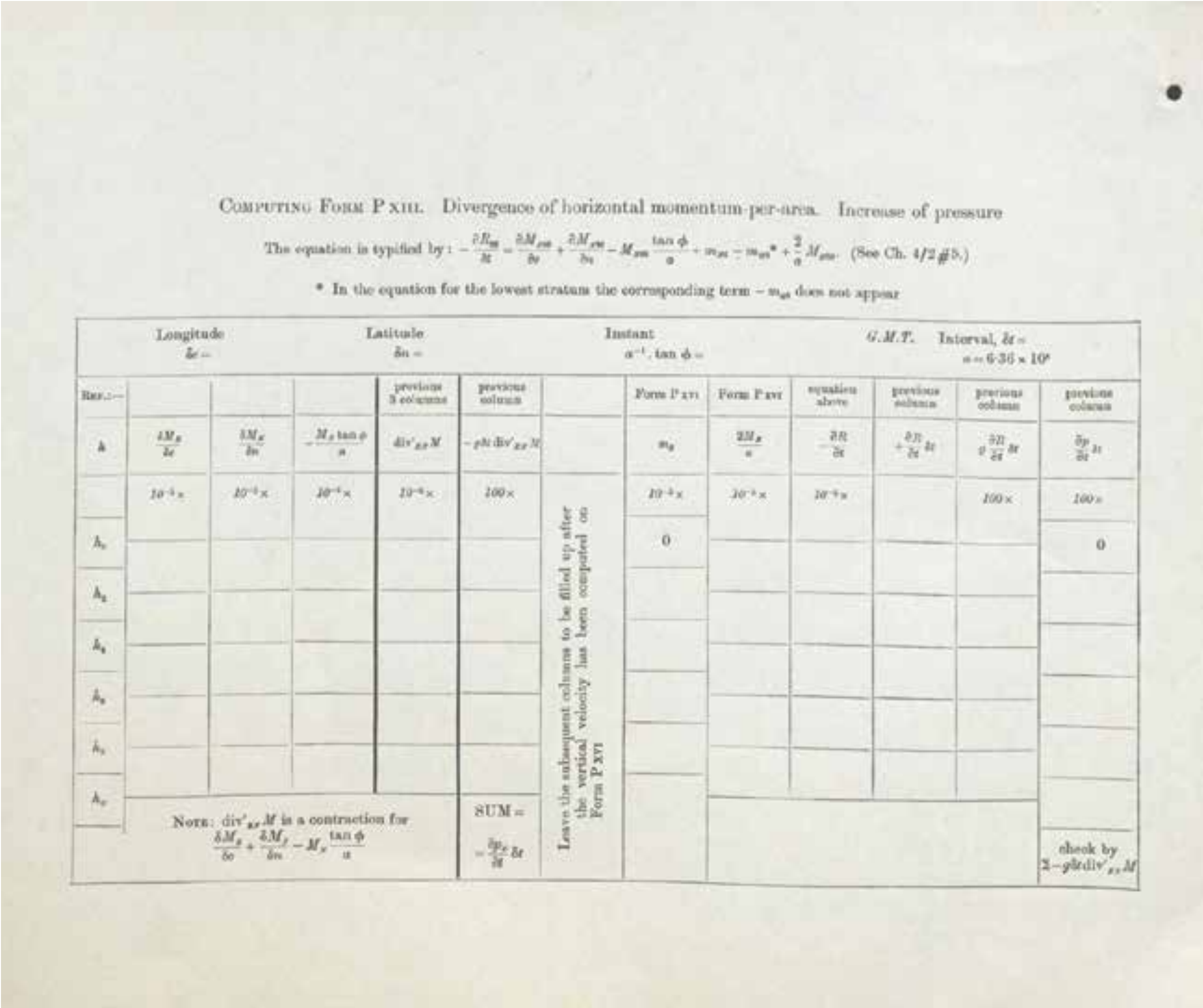




The Forecast Factory, image courtesy of Bengtsson L.

Illustration from Richardson L. F., *Weather Prediction by Numerical Process,* Cambridge University Press, 1922

Weather Prediction By Numerical Process
- a Forecast for Europe,
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Installation view during the performance
Photo Lise Autogena & Joshua Portway



COMPUTING FORM P XIII. Divergence of horizontal momentum-per-area. Increase of pressure

The equation is typified by: $-\frac{\partial R_{H}}{\partial t} = \frac{\partial M_{Ee}}{\partial e} + \frac{\partial M_{Nn}}{\partial n} - M_{Nn}\frac{\tan\phi}{a} + m_{H} - m_{H}{}^{*} + \frac{2}{a}M_{Hn}$. (See Ch. 4/2 # 5.)

* In the equation for the lowest stratum the corresponding term $-m_{H}$ does not appear

Longitude $\delta e =$			Latitude $\delta n =$			Instant $a^{-1}.\tan\phi =$			G.M.T.	Interval, $\delta t =$ $a = 6{\cdot}36 \times 10^{8}$	
REF.:—				previous 3 columns	previous column	Leave the subsequent columns to be filled up after the vertical velocity has been computed on Form P XVI	Form P XVI	Form P XVI	equation above	previous column	previous column	previous column
h	$\frac{\delta M_E}{\delta e}$	$\frac{\delta M_N}{\delta n}$	$-\frac{M_N\tan\phi}{a}$	$\mathrm{div}'_{EN}M$	$-g\delta t\,\mathrm{div}'_{EN}M$		m_H	$\frac{2M_N}{a}$	$-\frac{\partial R}{\partial t}$	$+\frac{\partial R}{\partial t}\delta t$	$g\frac{\partial R}{\partial t}\delta t$	$\frac{\partial p}{\partial t}\delta t$
	$10^{-5}\times$	$10^{-5}\times$	$10^{-5}\times$	$10^{-5}\times$	$100\times$		$10^{-5}\times$	$10^{-5}\times$	$10^{-5}\times$		$100\times$	$100\times$
h_0							0					0
h_2												
h_4												
h_6												
h_8												
h_G												
	NOTE: $\mathrm{div}'_{EN}M$ is a contraction for $\frac{\delta M_E}{\delta e} + \frac{\delta M_N}{\delta n} - M_N\frac{\tan\phi}{a}$				SUM $= -\frac{\partial p_G}{\partial t}\delta t$							check by $\Sigma - g\delta t\,\mathrm{div}'_{EN}M$

Pressure calculation form from Richardson's accompanying book *Forms whereon to write the numerical calculations* described in Richardson F. L., *Weather Prediction By Numerical Process*, Cambridge University Press, 1922, 14

The Forecast Factory: A personal Reflection

Jutta Thielen-del Pozo

Why did I become a meteorologist? Why am I fascinated by weather? Perhaps because of these moments when my grandfather would sit there and say “I can feel the scars in the arm I broke 50 years ago. Heavy rain is coming tomorrow”. And sure enough, it would rain. Or he would say “Ah, we can hear the church bells from this town. The weather is going to change.” He was right, of course, every time. My grandfather was a farmer and he needed to observe and know these signs. He was very good at observing and establishing correlations. It fascinated me. I started to take records of temperatures and rain, I wanted to document those correlations and find patterns. But I too often forgot, and without regularity – no pattern. I started to admire people who have the energy, fascination and stamina to do the same measurements and observations over and over again, every day. It was a relief to think that such observations could be automated. It would make weather observation and forecasting a lot less dependent on people like me – and be a lot more reliable.

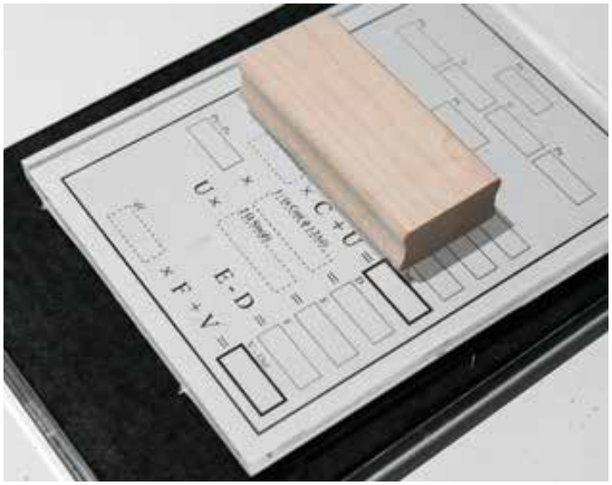
When I started studying meteorology, it all started to make sense and the physics behind explained the correlations – hot air moving up, cold air down, air mass moving from high pressure systems to low pressure systems, mountains blocking the air flow. The causalities behind the correlations explained why the different clouds formed, why red skies at sunset mean usually nice weather the next day. The weather-climate system is not random but causal – and extremely complex, driven by uncountable processes at the land-sea-atmosphere interfaces. Measuring the state of the atmosphere, analysing what the actual weather is and predicting what is going to happen is a daunting and challenging task – one that cannot be done anymore with a pencil and a piece of paper. The amount of data that needs analysing and the number of equations that need solving are simply too much to be done by hand and by a single person.

Pioneers such as Lewis Fry Richardson, a British physicist, attempted it anyway. By simplifying the equations and making some bold assumption, he made one of the first weather forecasts – and it took him over 2 years to complete his calculations by hand. However, it is the work of Richardson and his colleagues at the time that set the path for numerical high speed weather and climate forecasting today. He spawned a grid over the globe and solved the equations for every grid point. If an air parcel with a temperature of 20 degrees moves steadily from west to east with a speed of 10 km per hour, where is this air parcel going to be tomorrow? By hopping from grid point to grid point, calculating the differences between two points, averaging values around the grid, Richardson calculated how the air could move in the coming steps. Richardson was a visionary, imagining how it would be if not one person was calculating but thousands of scientists. If this grid was very fine and at every grid point a person would be calculating, handing over information from one point to another – could we do a faster weather forecast?

Today we know this is possible, only not with humans but with computers. The higher the computer power, the more processes can be looked at, the more we can deal with the uncertainty in the measurements, predict possible scenarios, resolve the dynamic and chaotic processes in nature. And up to this day, weather forecasting models are grid-based. On regular or more or less regular grids, the equations of motion and thermodynamics are solved: the movement of air, the rising or cooling of temperature, forming of clouds, rain and hail, in short, everything that we observe as weather, is all calculated. A grid structure seems intuitive. After all, we are already used to longitudes and latitudes. As the programmes have become more complex, more processes and interactions have been included, the basic structure of the grid and the basic equations have stayed the same. In fact, we also have adapted the observational network to the grid, adding data points where the model required them. The weather services have tried to-space the observations to spawn the globe and the data are collected in regular intervals, every 24, 12, 6, 3 hours or even hourly.

However, I often wondered if the regular grid is the best model for atmospheric processes? Hydrologists have come up with other grids and units, why not atmospheric physicists? What if we could feed a machine learning algorithm with all the observations and all the data that are measured daily, every second – from the weather stations and satellites, but also irregular and random data collected from planes, ships, cars, rivers, fields, houses, photos – would the AI algorithm come up with the same predictive models? Would it also work on a grid or would it come up with other units? Units such as cloud fields? The upper and lower systems of the atmosphere? Units that change along the calculations, morph themselves as the weather evolves?

When talking to Lise and Joshua about how the Louis Fry Richardson code could be realised, the first thoughts were to arrange people along a grid with each person calculating independently. But slowly the question arose: what if the participants became the variables? What if they were the air parcels moving around? What if they clustered? Joshua made me understand just how much my mind turned around the grid base structure. His ideas of people being the operators and swirling around in groups, changing meaning and purpose was just marvellous, catchy, and brought us all back to the idea: how about we let the AI rediscover our world and the laws of physics? And who knows: help us to discover better ways of finding meaningful units than the ones we are currently tied up with.



Weather Prediction by Numerical Process -a Forecast for Europe,
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Installation views during the performance
Photos Lise Autogena & Joshua Portway

The Forecast Factory: Art for Science

Florian Pappenberger

2019 is the 50th anniversary of the moon landing! I want to go to space, real space, outer space - not just 80km up, which is the boundary above which NASA calls you an astronaut. I want to marvel at our blue, gorgeous and precious planet from far away. Maybe I will make it up there, maybe I will not. From space, you can see the ocean, the continents, the curvature of the earth and you can also see the clouds. Clouds in all uncountable combinations of shapes and patterns. Sometimes, they are so fuzzy that you think you have forgotten to put on your glasses, and sometimes their features are crystal clear. Clear as the patterns of hurricanes and typhoons, which can be sharp as knives. From up there, they look fascinating and peaceful, hiding the devastation and hardship they bring. Hiding the wind and rain that they carry; hiding the floods that follow in their wake, hiding the inevitable human suffering they provoke.

Today we can fire up rockets to marvel at these clouds and we can heat up computer processors to calculate their patterns. We can forecast this hell on earth – not perfectly, not with 100% accuracy, not good enough – yet.... Weather forecasts have been improving step by step over the last decades, quietly revolutionising people's lives with significant, increasing success in predicting disasters. Going to space and forecasting the weather is made possible by two key factors: computers and humans. Two essential components, which also form the beating heart of Lewis Fry Richardson's Forecast Factory, described in his book *Weather Prediction by Numerical Process* – published in 1922. Weather Forecasts are based on computations using equations that represent the physical principles governing our planet. Hundreds of lines of code, millions of earth observations and billions of brain cells are required to resolve and develop these complex simulation models. Long before the arrival of any real computers, Richardson devised a complicated yet sophisticated method of solving these equations by hand. The method required, to all effects, a fantasy world, which in turn was a lush utopia for every weather enthusiast.

An enormous building in the shape of a globe, the hull of the globe segmented into areas like the cells of a honeycomb. Each cell hosting a busy bee, aka a human computer, who manually and painstakingly calculates the solutions to weather equations very carefully, interacting with the neighbouring cells and directed from the centre by the queen, the Director of Operations. Then, a village with workers, clerks and scholars supporting each cell and the entire operation. This utopia never came to life, and when Richardson tried his method, it failed. It was a disaster. It never would have worked – but it is the foundation of modern computer-based weather forecasting.

Many illustrations of this forecast factory exist, some very simple, some showing intricate details (look for the painting by Stephen Conlin from 1986). Lise and Joshua's idea of realising it with real people, in a real space, simulating a real forecast is fascinating. Their concept is stimulating, their questions are fundamental, their vision is entangling: how do you truly compute fundamental physical equations in a simple way without any device instruments? How do you communicate? And shouldn't the people move like air particles? How real can reality be? Forecasts are calculated today on computers with the lighting speed of a shooting star. In comparison, the human forecast will be calculated with a speed that will be equivalent to the light of a star arriving on earth long after it died – producing a forecast past its sell-by date.

I can't wait to see Joshua and Lise's work!

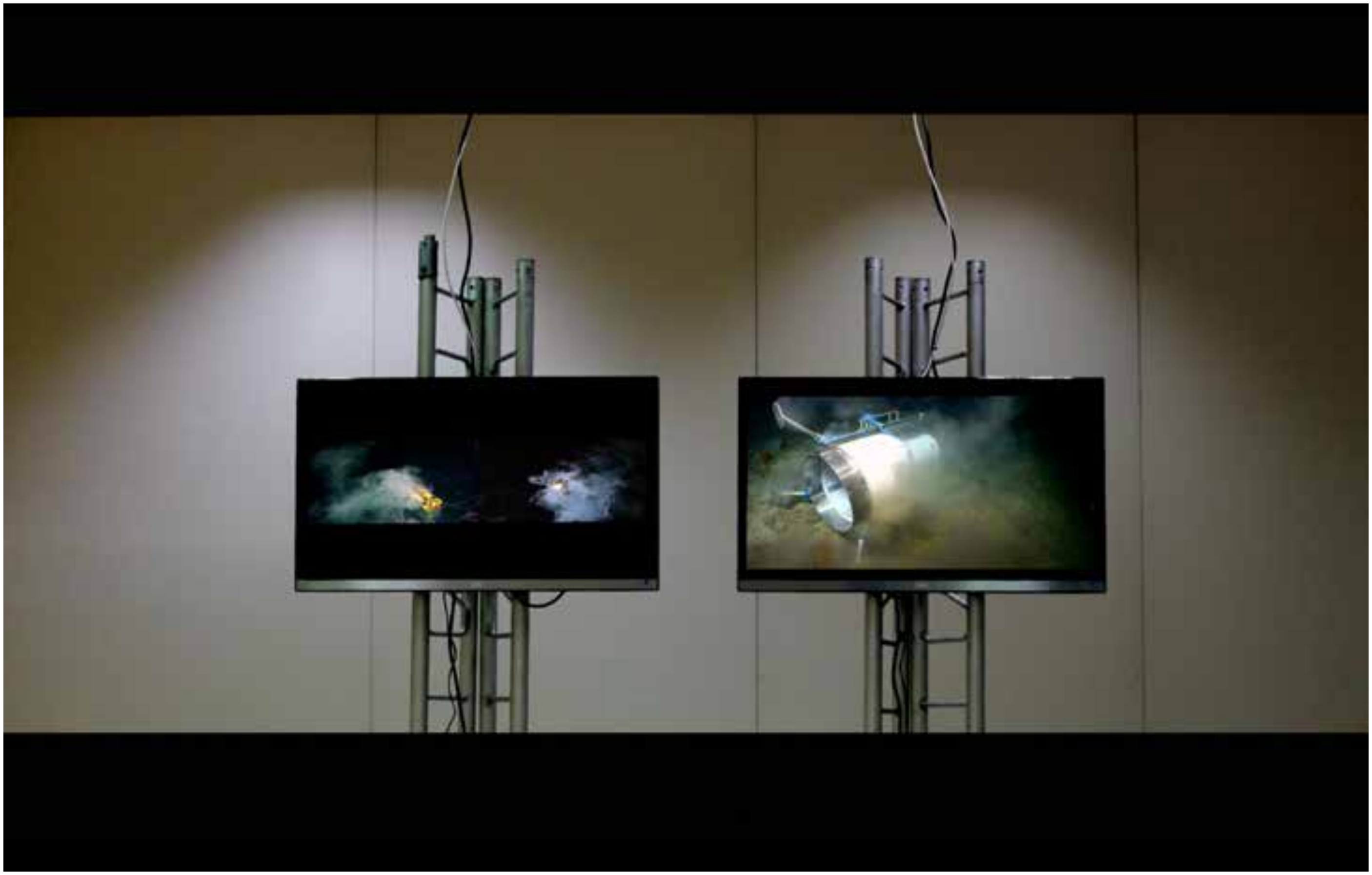
B-scope, C-index

Artist
Martina O′Brien

Scientists
Alessandro Annunziato
Daniele Galliano
Thomas Petroliagkis

Collaborators
Florian Pappenberger, ECMWF-European Centre
For Medium-Range Weather Forecasts
Aaron Lim, University College Cork
and University College Dublin

B-scope, C-index,
SciArt Datami project 2019
Two-channel HD video & audio, 12′30″, printers



B-scope, C-index,
Resonances III Datami
Festival JRC-Ispra site
15 October-8 November 2019
Installation view
Photo Martina O’Brien

B-scope, C-index

Martina O'Brien

In recent years, with escalating climate concerns, interest in our oceans increased distinctly. From residents on islands, such as Ireland, to scientists across the world, seas and oceans are increasingly observed and analysed. As global citizens and consumers of the Earth's natural resources, the materiality and systematic functionality of oceans affect us all – from the quality of the food we eat daily e.g. microbead contamination, to our habitats' rainfall levels , to coastal erosion and rising water levels. In today's contemporary society, the ocean is studied in many different ways by those whose lives are immediately affected by the water: fishing companies and coastal residents, and scientists who use the oceans as subjects of digital study.

A new installation of artworks presented by artist Martina O'Brien explores one such oceanic area - the North East Atlantic Ocean and its coastal regions – an area especially relevant to Ireland, the UK, and Europe. Video artworks and real-time datasets, titled *B-scope, C-index*, focus on the tide in this region of the Atlantic Ocean, and explore, in particular, cutting-edge wave observation systems and data collection processes.

B-scope is a two-channel HD video and audio artwork. The video features footage taken by the artist during a recent residency aboard the research ship *The Celtic Explorer* in the North East Atlantic Ocean. The artist accompanied Dr Aaron Lim on the *Monitoring Changes in Submarine Canyon Coral Habitats survey*, on their expedition to the Porcupine Bank. The opportunity enabled her to capture video footage from the survey's underwater Remotely Operated Vehicle (ROV) cameras. This underwater mission was to place a benthic lander - an observational platform that sits on the seabed to record physical, chemical or biological activity - in a previously unobserved area of the ocean's floor, a *terra incognita*.

The underwater vehicle, physically linked to the host ship by an umbilical cable, descends and ascends to and from the ocean floor. Journeying above and below the horizon line, this artwork is an inquiry into vertical perspectives, as a counterpoint to the more familiar horizontal perspectives that explore life on Earth's crust and its lived atmosphere. The camera acts as a sensor, giving humans the opportunity to spectate the hostile ocean floor, and providing detailed on-the-ground information to corroborate distantly gathered data.

For the duration of this exhibition in Ispra, the installation includes a printer that visually processes the live-feed ocean wave data from the ROV expedition, and displays ocean wave model forecast datasets. This data is provided by The European Centre for Medium-Range Weather Forecasts.

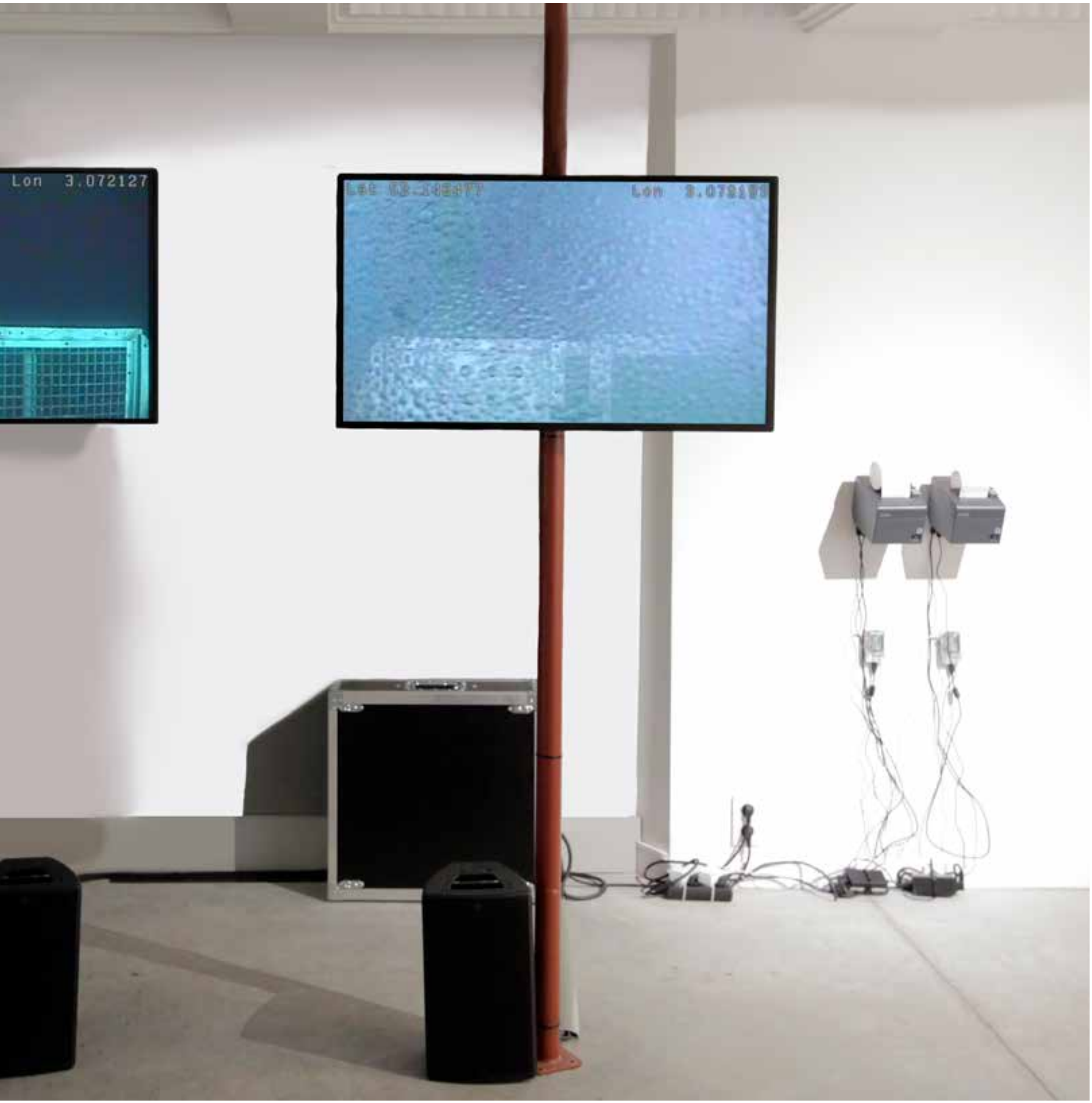
Furthermore, the recent ROV dive featured in *B-scope* took place on 15th May – a date that inadvertently aligns the expedition with four other significant journeys of exploration. These explorations, contributing to the Space Race, included the Soviet Union's launch of Sputnik 3 in 1958 and Sputnik 4 in 1960, the USA's launch of Mercury-Atlas 9 in 1961 and the Soviet Union's launch of the Polyus spacecraft in 1987 (all launched 15th May).

This shared launch date links the European expedition's dive and its location in the Atlantic with historical expeditions that also journeyed perpendicularly to the horizon, albeit in the opposite direction. In the contemporary case of the ROV dive, this expedition's mission is a sign of the times; rather than pushing the boundaries of humanity's achievements regardless of the environmental consequences, scientists are now trying to predict future catastrophes to buy us more time on Earth.

C-index, a corresponding HD video artwork, explores the infrastructure, big data and governance of early warning systems for rising sea levels and location-specific hazards, such as tsunamis. In par-

B-scope, C-index,
Resonances III Datami
Martina O’Brien,
materials, 2019

B-scope, C-index
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Installation view
Photos Riccardo Pareggiani,
Martina O'Brien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B-scope, C-index,
Resonances III Datami
Martina O'Brien,
materials, 2019

ticular, this artwork focuses on Ireland's first *Inexpensive Device for Sea Level Measurement* (IDSL), recently installed on the island of Inishmore, on Ireland's west coast, on the North East Atlantic Ocean. An IDSL is a gauge, also known as a mareograph, that measures the sea level in real-time. This information is transmitted to servers at the European Commission's Joint Research Centre through General Packet Radio Services (GPRS) communications, thus immediately available for analysis. Tsunami early warning systems are based on observation networks of seismometers that respond to ground motion, in addition to sea level measuring stations. Combined, these systems send real-time data to warning centres, in Ireland and abroad.

The physical tools that comprise the installation – monitors, cameras, printers – are each expressions of the environment they depict. The artworks offer perspectives, via these sensory devices, on contemporary science that looks to nature to proffer the future.

Resonances III Journey

The process of developing a project for Resonances III proved to be an interesting journey, one that was initiated by the SciArt Summer School in 2018. This weeklong platform, filled with numerous presentations from selected scientists, curators, academics and fellow artists, was a rare opportunity to become acquainted with the EU's Scientific Hub in the Joint Research Centre. Throughout the five-day programme I was introduced to research areas that were previously unfamiliar to me. For example, I got to hear about smart city designs, policy, genomics, etc., all through the lens of big data.

Laboratory visits were organised to a number of scientific research units and this is where I was introduced to the inner workings of the Crisis Management Room in the European Crisis Management Laboratory. In particular, I was fortunate to be introduced to Meteorologist Thomas Petroliagkis, and through conversations we discussed many compelling potential starting points for a project, which gave me a lot to consider. Through the Speed Dating session, I made a salient connection with Louise Arnal from The European Centre for Medium-Range Weather Forecasts (ECMWF) and as a result, the chance to collaborate with their Director of Forecasts Florian Pappenberger arose.

While on residency in ECMWF to develop my collaboration, I spoke with Florian and many of the scien-

B-scope, C-index,
Resonances III Datami
Martina O’Brien,
materials, 2019

tists working in areas including wave forecasting, remote sensing, coastal and river flooding, and archival data handling. Furthermore, I had the opportunity to ascertain more about the importance of ocean wave forecasts and their importance in weather forecasting and climate modelling, as well as for coastal communities, shipping routes and offshore industry. All of which fundamentally informed major parts of my project.

In addition, I had the chance to witness the operations of MARS - ECMWF’s Meteorological Archival and Retrieval System; a robotic tape system which holds the largest archive of numerical weather prediction data in the world. For more than thirty years, ECMWF has operated this large-scale data handling system, on which users can store and retrieve data needed to perform weather modelling and mining of weather data. Given that up to 80 million observations are recorded from land, sea, air, ship and satellite on a daily basis, the growth of this data collection and consequential storage is an on-going issue. They currently have over 300PB (300,000 terabytes) of data which is accessible to their users and the size of the archive is expected to continue to grow, reaching 900PB by 2022.

The Artist-in-Resonances programme was an opportunity to spend additional time in the Joint Research Centre’s campus, allowing artists to meet with scientists from their chosen scientific area of interest, with an aim to further develop concepts for the Resonances III Festival. It was beneficial to have had this residency divided into separate timespans, as it allowed for an incubation period between stays at the site, enabling natural progression to take place within my research.

As I started to think about parts of my proposal, it became apparent that my interest in the European Crisis Management Laboratory’s research was predominately in the area of their sea level monitors – *Inexpensive Devices for Sea Level Measurements* (IDSL’s). It was curious and peculiar for me, living in Ireland, to learn that up until 2018 these devices had largely been installed in and around the Mediterranean Sea and in a small number of North Atlantic areas, but that there was now a pertinent need to install such a device in Inishmore, one of western Ireland’s Aran Islands.

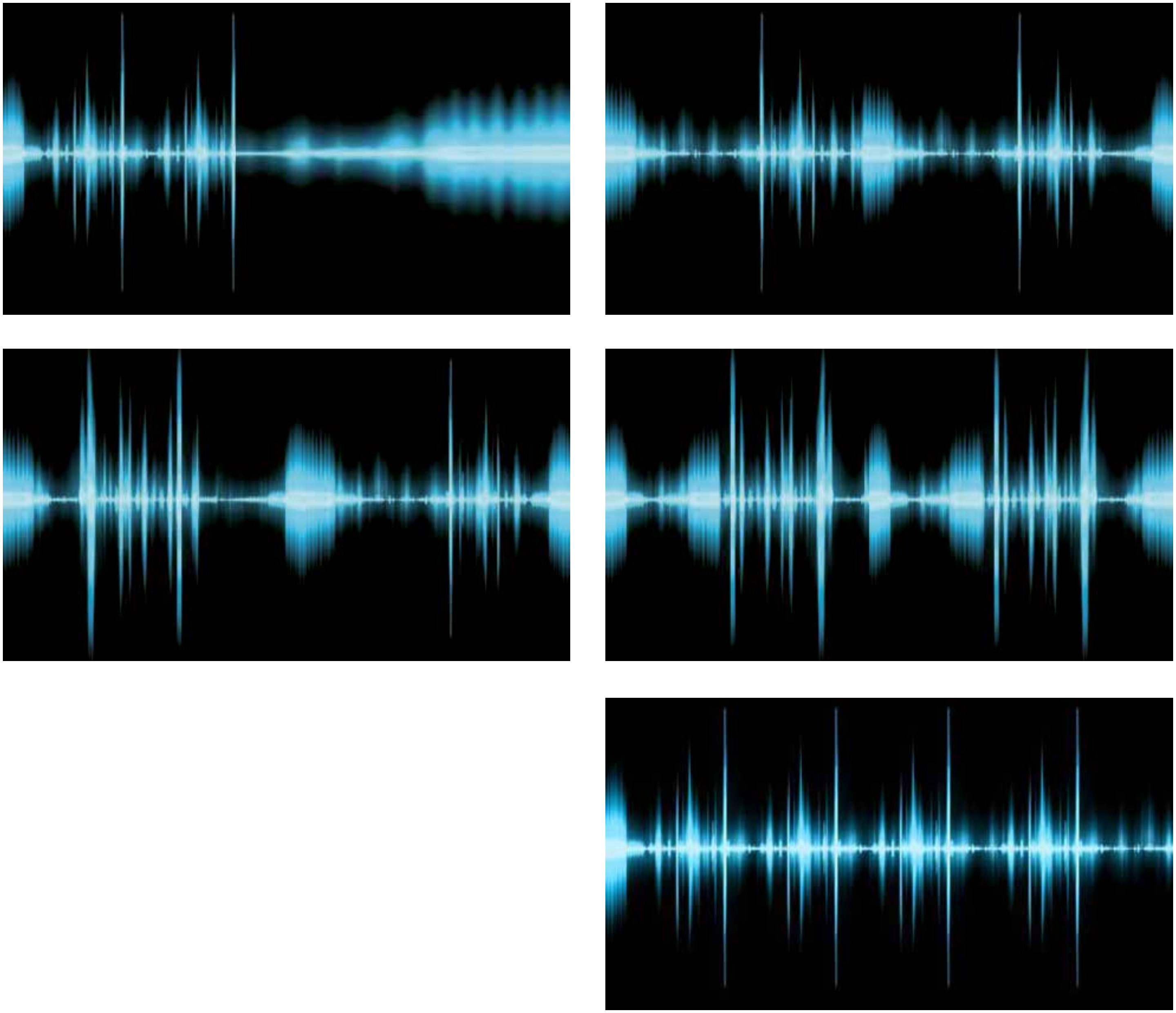
Ireland’s history has rarely featured an occasion such as a tsunami. The consequences of climate change may however prove that our future is written otherwise.

Nature of Knowledge
-The Uncertain Structure

Artist
Jenny Brockmann

Scientists
Marcelo Masera
Pierre Pegon
Diana Rembges

Nature of Knowledge - The Uncertain Structure,
SciArt Datami project, 2019
Installation, 3 x 10 x 6 m
Mixed Media: Aluminium, Acrylic glass, smart foil, controller



Nature of Knowledge
-The Uncertain Structure,
Resonances III Datami
Jenny Brockmann,
depiction of the sound emitted
by the installation, 2019

Nature of Knowledge - The Uncertain Structure

Jenny Brockmann

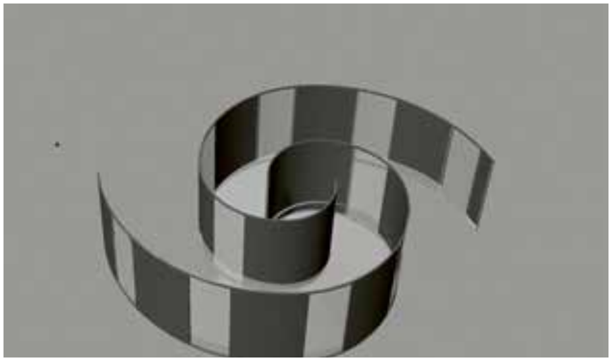
Uncertainty in science poses a problem, but for me as an artist uncertainty is a chance: I want to achieve the in-between, a state of uncertainty within my work, because then we really have to struggle. Only when we struggle do we get somewhere. A fundamental question is how to have knowledge within and between all the data.
Jenny Brockmann, 2019

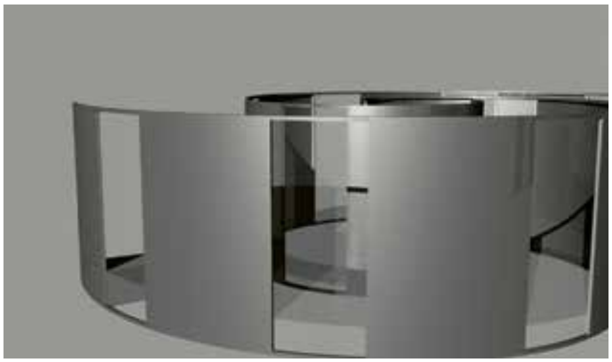
The SciArt Experiment

The consequences of climate change depend on the quantity of greenhouse gases we release into the atmosphere, triggered by increasing temperatures, and humanity's reaction, with knowledge of these consequences. All of these factors are uncertain. The amount of greenhouse gases still being released depends, among other things, on human behaviour, technological developments, and population growth. Uncertainty about the resulting temperature grows as a result of many types of feedback from the climate system. Some consequences of these increasing temperatures are predictable, but surprises are virtually guaranteed. This is especially true given the uncertain conditions, and their complex relationships with humanity's other environmental impacts, as well as humankind's generally unpredictable strategies for adapting to climate change.

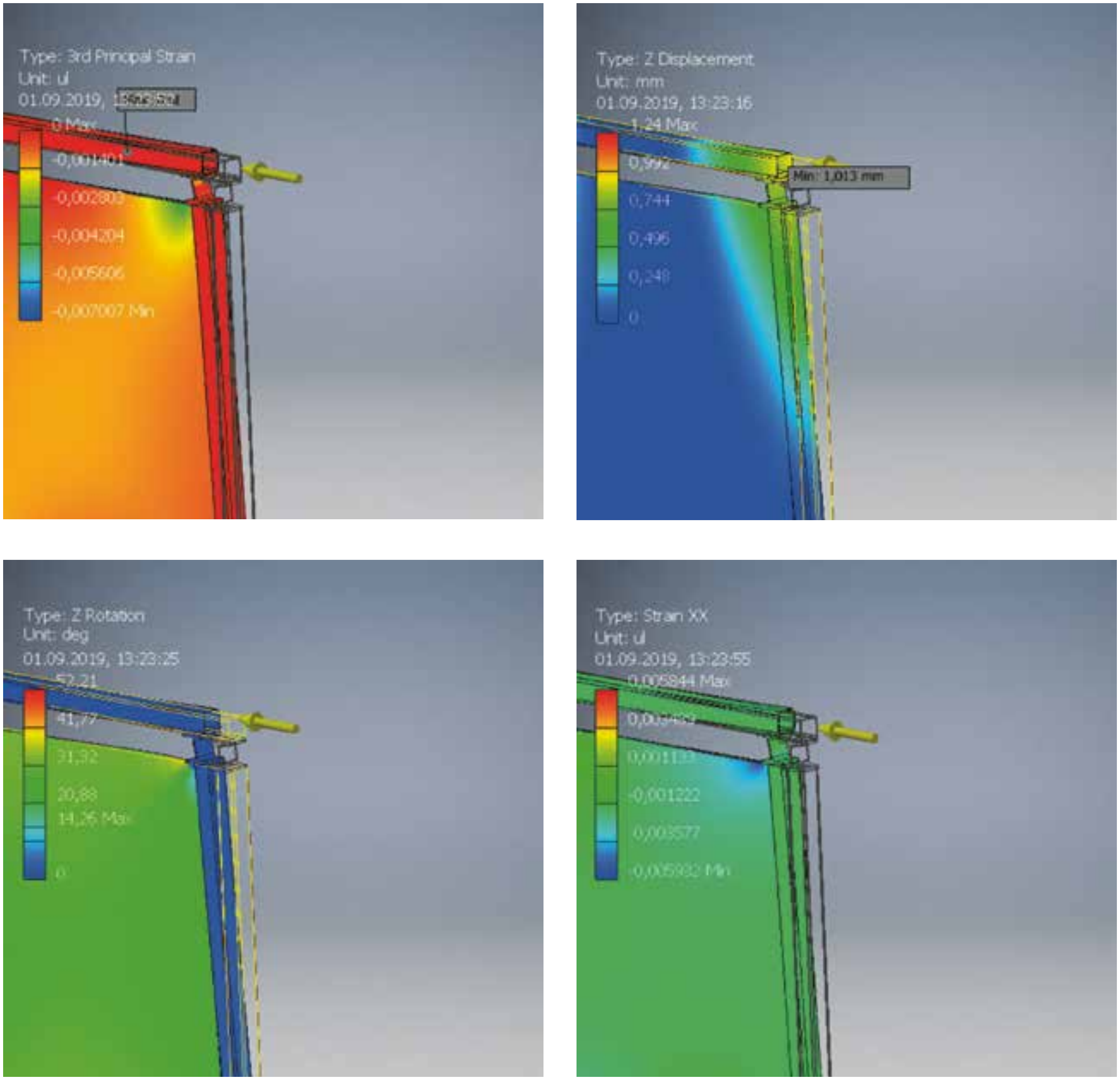
One of the topics of this project is how the forecast concerning the arrival of a point of irreversible transformation is uncertain, together with the uncertain process of knowledge production and transfer.

Generated by a real-time experiment at the JRC, *Nature of Knowledge* - the Uncertain Structure transfers data dealing with the consequences of climate change into a spatial installation in the shape of a spiral at the VELA 9 Lab (JRC, Ispra, Italy) and BOZAR (Brussels, Belgium). The art historian and historian of science Hans-Jörg Rheinberger writes in his Essay, *The Aura of the Spiral*, that, although we find the formal principle of the spiral as a natural form, above all in organic structures, the aesthetic interest in it has always been culturally shaped and as such has undergone manifold figuration in human history. The oldest spiral form known to us can be found in Neolithic pottery; the spiral form provided

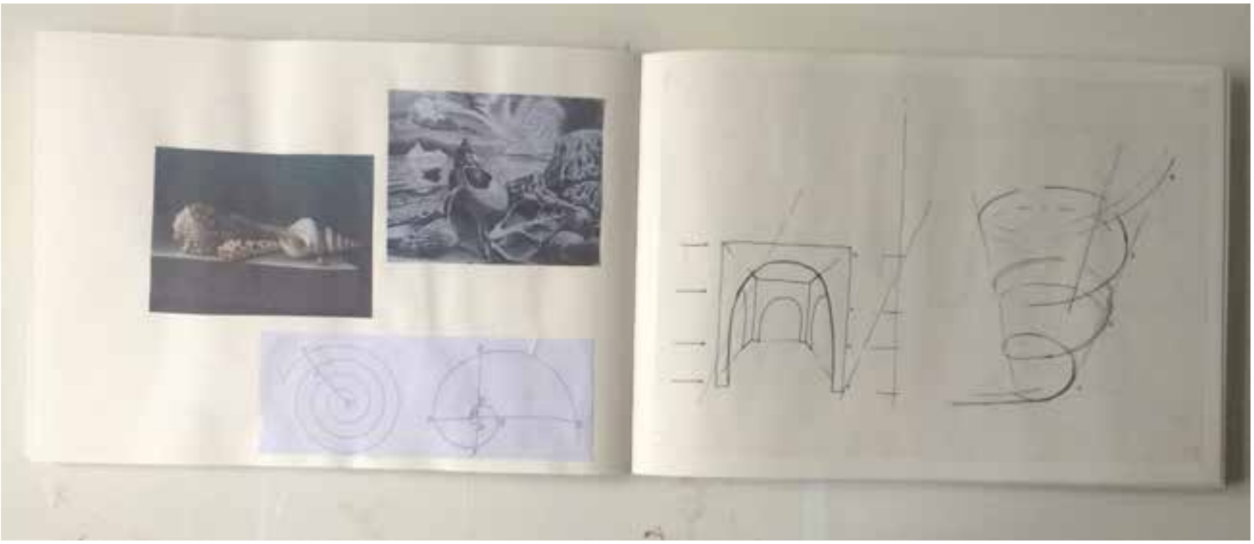




Nature of Knowledge -
The Uncertain Structure
Resonances III Datami
Jenny Brockmann, visualization of the spiral structure B, 2019



Nature of Knowledge – The Uncertain Structure
Resonances III Datami
Jenny Brockmann, materials, 2019
Simulation of the impact of the imposed force on structure A, 3rd principal strain
Simulation of the impact of the imposed force on structure A, displacement of the structure
Simulation of the impact of the imposed force on structure A, rotation of the structure
Simulation of the impact of the imposed force on structure A, strain



mathematical basis for the calculation by the Hellenistic mathematician Archimedes, and Leonardo da Vinci and Johann Wolfgang von Goethe were inspired by the spiral in their works in literature, art and science. Today the spiral offers important references in the arts as well as in the sciences.

A structure corresponding to the test structure at the European Laboratory for Structural Assessment (ELSA) of the JRC is built at a remote location and put under increasing stress throughout the duration of the exhibition. This structure becomes more and more strained under the deforming pressure of mechanic devices at ELSA that simulate geological movements and states of the atmosphere. Eventually, the structure will be permanently disfigured. The spiral-shaped installation is connected in real time to the data of the experiment, and transforms in time according to the data created by the smart energy of the deforming structure, relating with the materiality of glass to the transparency needed for the implementation of a smart society as researched by SGILab. Accidental and deliberate factors like visitors' paths through the space, or physical data like temperature and pressure, lead to the creation of certain variables in the experiment. These add a random eleme to the overall uncertainty of the project, while creating an integrated form of communication: opening a social channel of interaction between the observers, the element being tested and references to people's mixed opinions on the rate of climate change.

This uncertainty provides a contrast to the expected trajectory of the experiment. Influenced by previous data, experiments, or models, expectations arise regarding the duration of the experiment and the moment when the structure becomes irreversibly transformed. The life expectancy of the experiment is updated continuously, according to new knowledge. This enhances the dichotomy between what we know about the ongoing phenomena, and the anticipation of what might happen, while affecting our "memory": our understanding of what has happened up until that moment.

'Uncertainty can be scary and poses the question of how to find ways not to be scared of uncertainty',

'A design engineer has to deliver facts and numbers, which are supposed to be certain and there is no chance of failure (handling with a part of uncertainty)',

'Uncertainty is a fundamental ingredient of the research process',

‘A quality of human behaviour is to be uncertain or act in an unpredictable/uncertain way’

(Quotes from the scientists during the conversation between Jenny Brockmann and ELSA Team in spring 2019)

The core research activities of JRC’s European Laboratory for Structural Assessment (ELSA) are developed in support of the standardization of construction, and for assessing the physical vulnerability of critical structures. The main provision at ELSA is a Reaction Wall, unique in Europe, due to its size and capabilities. By means of computer controlled hydraulic actuators, it is possible to expose full-scale structures to significant dynamic forces and control the resulting movements with high precision. The wall and the floor are designed to resist the forces, typically several MN, which deform and seriously damage the test models.

It allows for the testing of structures at full scale, in order to assess behaviour when exposed to earthquakes or other types of cyclic loads. Work related to existing structures includes the development of techniques for their strengthening or repair, validated by representative models. Another resource at ELSA is a large Hopkinson bar (HopLab) that facilitates dynamic testing of materials and structures subjected to extreme loads, simulating high strain rates are representative of impact and explosion.

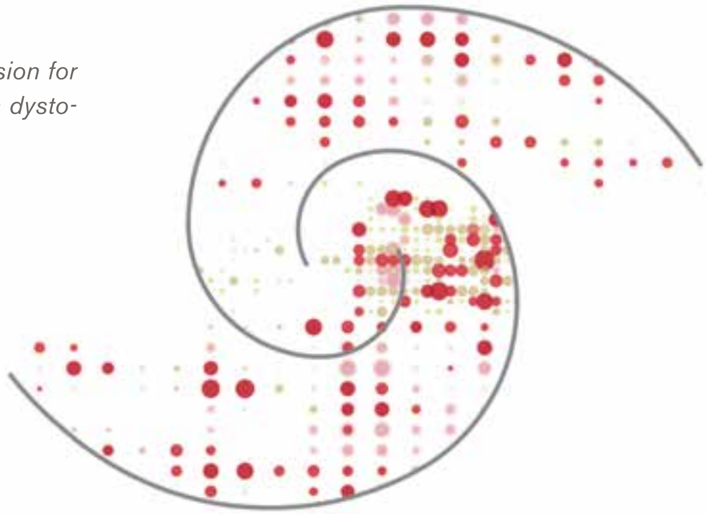
‘For the majority of citizens, there is no vision for the (uncertain) future (not an utopia nor a dystopia), it is a matter of fact that we lose (physical, biological) abilities (e.g. to be capable to see in the dark) and gain new ones (through technical prosthesis)’

‘Foreseeing the transformation and creating a vision, including future planning for energy, heating and communication is the first step to transform an uncertain state in a certain reality’

‘We all have conflicting links with knowledge (requiring more of it, or disbelieving so called experts), accept and fear uncertain data processes (from their collection, to their end use), suffering from our awareness of the limited/uncertain perception of reality, etc. The main difference is that the scientists (or at least many of them) are trained to deal with uncertainty on the technical side. Nevertheless they are not well prepared for dealing with the political, social and ethical uncertain impact of their work’

(Quotes from the scientists during the conversation between Jenny Brockmann and SGILab team in spring 2019)

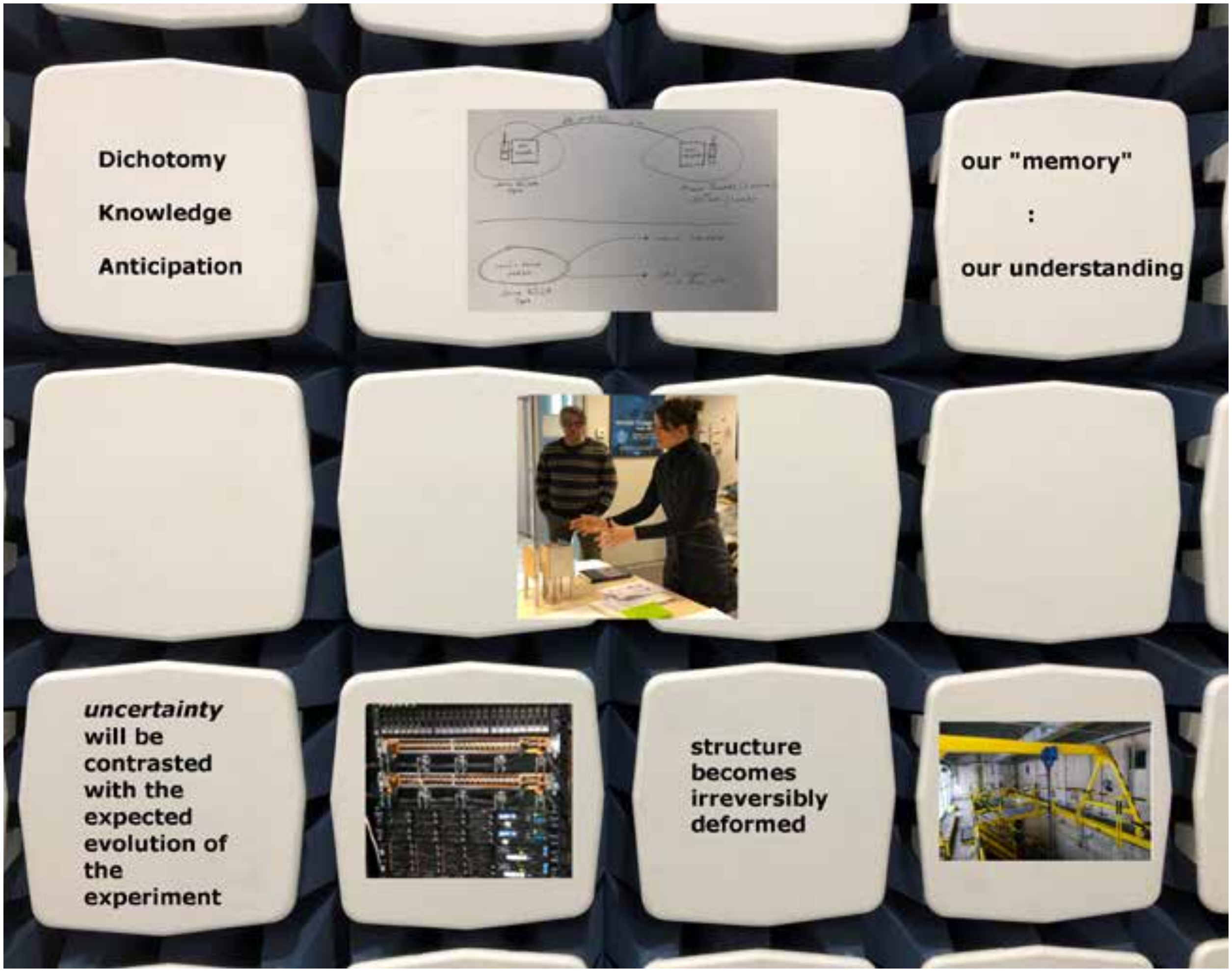
The Smart Grid Interoperability Lab (SGILab) of the JRC’s Directorate on Energy, Transport and Climate is a testing



Picture on the previous page:
Nature of Knowledge
-The Uncertain Structure,
Resonances III Datami
Jenny Brockmann,
Photo of a page from the
sketchbook for the project, 2019

Image on this page:
Nature of Knowledge
-The Uncertain Structure,
Resonances III Datami
Jenny Brockmann,
visualization of the movement
by the audience through the installation spiral structure B, 2019

Nature of Knowledge
- The Uncertain Structure,
Resonances III Datami
Diana Rembges,
Strips of research between
different JRC groups with Freddy
Paul Grunert and Jenny Brockmann
JRC Ispra site, 2019


Dichotomy
Knowledge
Anticipation
our "memory"
:
our understanding
uncertainty will be contrasted with the expected evolution of the experiment
structure becomes irreversibly deformed

Nature of Knowledge
- The Uncertain Structure,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view of structure B
in the anechoic chamber VELA 9
Photo Paolo Vandrasch

Nature of Knowledge
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Installation view of structure B
in the anechoic chamber VELA 9
Photo Jenny Brockmann

facility for the interoperability of smart grid systems. Its aim is to assess technological implementation according to proposed standards, using cases and processes in conjunction with applicable models. The goal is to contribute to policymaking and industrial innovation of the electric grid's modernization. The lab works on the different layers of smart grid architecture, from protocols and communications, to devices and subsystems. It verifies interactions between grid components, benchmarks of different solutions, and identifies of gaps and challenges.

The work is performed in collaboration with industry and research institutions. It is equipped with real time simulators, an energy storage unit, and an Information and Communication Technology (ICT) Suite, enabling the emulation of complex communication settings. The lab aspires to apply the best available experiment design and analysis methodologies, and disseminate the results to all relevant stakeholders.

Notes on Uncertainty - Research

The dislocation of material and data refers to the crucial fact that, in our present time, objects and things are removed from their original locations, to be transferred to different ones, as described by Michel Foucault (1967). The installation determines paths, ways, and social interactions throughout the exhibition space. According to the phenomenology of Edmund Husserl (1936), Maurice Merleau-Ponty (1945), and also in Immanuel Kant's “experiential space” (1781), what we experience with our senses exists in our consciousness. Only then are we able to experience space, and project our thoughts and memories into it.

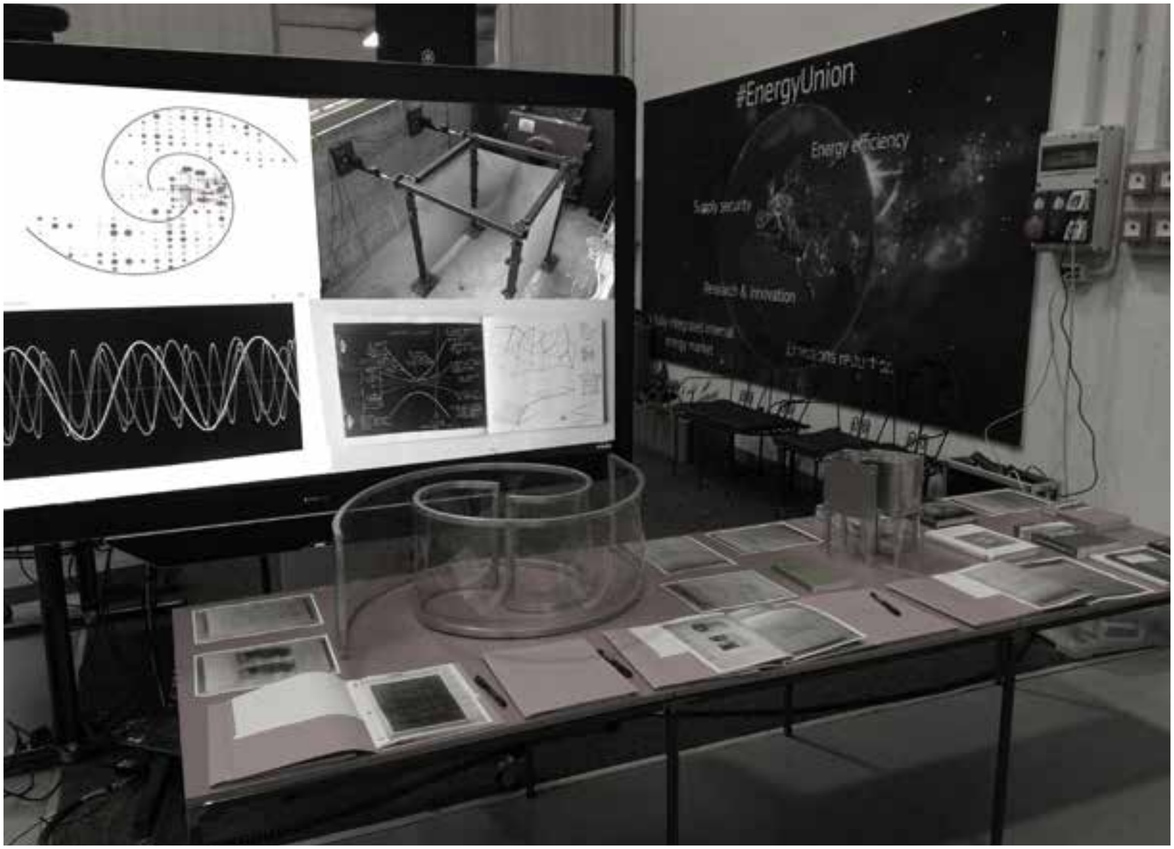
In the experimental spatial arrangement in the exhibition space, it is presupposed that creating an architectural space will have a retroactive effect on our perception, and consequently, on our movement and interaction. In reference to the Internet of Things, through integrated communication, the process at ELSAJRC, determines the form and the process of the

Nature of Knowledge
- The Uncertain Structure
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Installation views of structure B
Photos Riccardo Pareggiani,
Daniel Djamo

spiral installation at the exhibition space. In return, the movement of the audience through the installation informs back the process at ELSA. The exhibition presents a sensual environment to be physically experienced. Everything in the installation, from the forms and materials, to the way they move, is imparted with data from the experiment at ELSA, JRC, and the process at ELSA is imparted with data from the exhibition space.

The installation in the form of a distributed experiment includes qualities like warm/cold, dense/loose, dark/light, and different scales and colors, to only name a few. How is knowledge created through a space that can be experienced with the senses? What does the translation performance look like? How much information gets lost when measuring real-world phenomena in the form of data? What are the advantages, but also limits, of data? Data can be seen as a (mathematical) language, ubiquitous in the natural sciences.

The project aims to make visible the process of different phases of knowledge production, knowledge transfer, and interpretation of knowledge. With its placement at the site of the JRC lab, where the decision to make measurements is made, the project reveals foundations of knowledge production. By exploiting raw data, accessible only to a handful of scientists, and transmitting it through digital codes, it raises questions about knowledge transfer. The interpretation of this raw data, which is normally done by scientists and passed on directly to policy makers, takes place in the installation, through the physical experience of the audience. This is analogous to the phenomenological idea that the body is the only tool capable of encompassing the complexity of the "outer" space. The knowledge link established during the period of SciArt collaboration potentially influences both the scientific research as well as the artistic investigation. This bidirectional feedback provides a highly fertile ground for a dialogue that attracts also the attention of a non-specialised audience.



Nature of Knowledge
- The Uncertain Structure,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view of
structure A at ELSA
Photos Paolo Vandrasch,
Cristina Fiordimela

Installation views
of materials exposed
in SMART GRIDS,
Interoperability Laboratory
Photo Jenny Brockmann

Post-Digital
is Post-Screen

Josephine Bosma

Post-Digital is Post-Screen. Arnheim's Visual Thinking applied to Art in the Expanded Digital Media Field*

*Revisiting of: Josephine Bosma, Post-Digital is Post-Screen - Towards a New Visual Art, 2013

I. Introduction

If the interest in the post-digital seems to point at anything, it is that the usefulness of the digital as a discursive element in analysing the impact of technology in society and culture is waning. Digital technologies on the other hand only grow and proliferate. This raises the question: why do we need or want to discuss matters in terms of a post-digital condition if digital media do not seem to lose ground but rather expand? I suggest we use the term post-digital to establish new points of perspective to refine the analysis of digital media and digital technologies. I look at this issue in the context of art. Here, the digital realm tends to be perceived as screen-based. This tendency is validated by popular approaches in media art, most notably in Lev Manovich's *The Language of New Media*. To examine and understand art practices in which screens are not at the centre of a work a screen-based analysis does not seem to make much sense. I try to show the limitations of the screen-based approach of the digital through Alexander Galloway's analysis of this problem in his book *The Interface Effect*.

What is not directly visible is also less likely to be seen. Additional issues for art in the context of digital media seem to be the visual impermeability or the spatial dispersion of specific works and practices. What I mean with visual impermeability is the presence of somehow "hidden" structures, like network technologies, code and software processes, and even indirect influences of the Internet or of computer technology in specific works of art[1]. The perception of such works is mostly limited to traces and elements of the work our vision, hearing, and touch can detect. The interpretation of physical objects, or "artifacts", is part of the appreciation and perception of a work of art. Works of art whose structures or processes mostly escape the line of sight present a challenge for interpretation that has been explored from different perspectives.

Earlier approaches for example suggest using Jack Burnham's *Systems Aesthetics*[2] or Callon and Latour's Actor Network Theory (ANT)[3] as a basis for analysis of complex works of art in a technological environment. What these approaches lack however is a strategy to develop new visual models. The prevalence of the visual arts in contemporary art seems to suggest that developing a view beyond the screen may ask for an alternative visual approach, rather than a predominantly conceptual or actor network approach. Rudolph Arnheim offers a possible basis for such visualisation in his book *Visual Thinking*[4]. He explains how visualisations are an intrinsic part of thought and understanding[5]. He uses examples from science, where the awareness of processes, structures, and objects often precedes or even constitutes their visibility. This inner mind visualisation, is created through the observation and analysis of physical objects or effects, which Arnheim calls "patterns of forces", which the observer inevitably interprets based on prior knowledge of the world[6]. For art this means that perception of an individual work will still depend on an audience member's experience and knowledge of art, but this time in a post-digital context, a context whose possibilities and limitations are still largely unknown to the general audience. Such an experience and knowledge will therefore take time to develop.

The development of experience and knowledge largely depends on existing research, criticism, and theory in the field. Despite a widespread tendency to approach digital technologies as screen-based, practices and works that exist beyond the screen have been documented and analysed, mainly from within the media cultural field[7]. Their examples and mine show a diversity in practice and form in art in the context of digital technologies that remains largely obscured in the many screen-based approaches. To round up my proposal to take Arnheim's notion of models of theory as a basis for a new visual approach to art, I attempt to describe a few possible uses of Arnheim's theory in this particular context. Since the visualisations he proposes all depart from specific areas of research, I combine his notion of models of thought with approaches of critics and theorists from the field of media art and media culture. The new perspectives on the effects of digital technologies on art developed this way could, through their radical break away from the screen and their move into the darkness of the unseen, serve the critical potential of the post-digital.

II. The Bright and Blinding Screen

In her book *Where Art Belongs* the art writer Chris Kraus puts what she calls "digital forms" in the same realm as video[8]. She is but one of many critics and theorists that describe art in the digital realm in terms of the image and the screen[9]. The manner in which it is described is almost always negative. Computers are described as the present-day epitome of Guy Debord's *The Society of the Spectacle*, or as problematic because prolific image copy machines. Virilio, in all his poetic paranoia, expresses this feeling by equalising all screens, from the screen of the networked computer to the surveillance monitor: "What was still only on the drawing board with the industrial reproduction of images analysed by Walter Benjamin, literally explodes with the "Large- Scale Optics" on the Internet, since tele-surveillance extends to tele-surveillance of art.[10]"

This superficial view of the computer and digital media in general, is supported or at least barely countered by influential writers from the media art field. Lev Manovich's bestseller *The Language of New Media* describes the computer almost entirely in terms of cinema. Even the chapter called *The Operations*, after a chapter on screens, solely focuses on image editing and image sequencing[11]. In his book *The Interface Effect*, Alexander Galloway starts off with a respectful yet also critical analysis of Manovich' cinematic approach of new media. Galloway takes his criticism of this approach further by continuing his criticism to a related approach, that of remediation[12]. The theory of remediation draws a straight line from medieval illustrated manuscripts to linear perspective painting to cinema to television and lastly to digital media[13]. The radical transformations brought on by digital technology are explained only by stating it "can be more aggressive in its remediation[14]. Galloway however puts a radical new twist on remediation in digital media. He observes that, far from remediating a visual language like that of cinema, the computer "remediates the very conditions of being itself"[15]. In terms of art practice, this means that digital media remediate art as is, with all its complexities and contradictions. Digital media however do so from their own form of Dasein, which comes to be through their design and application.

The focus on the screen therefore is not a problem produced by digital technologies per se. To find a possible cause and solution for this problem it seems more appropriate to approach it as a continuation of issues in art criticism and cultural theory at large. Though a variety of approaches to discuss art involving digital technologies exists[16], "no clearly defined method exists for analysing the role of science and technology in the history of art" as a whole[17]. Edward Shanken notes how after the heydays of modern art historians stopped describing technological developments in art[18]. In this time period especially, digital technologies have prospered exponentially. This change in art historical method seems to have created a lack of analytical tools to grasp the realities of art in the age of digital media. What the ongoing screen-based analysis of digital media shows is that this causes the variability and techno-political issues of the digital in art and culture to go largely unnoticed.

III. What is Visual Thinking

To bridge the gap in knowledge about art and technology it seems first of all necessary to look at the role of technology in art in another way. The term post-digital seems to suggest we take a certain distance from the digital, or that we at least question what the term has come to stand for. This distance and questioning may provoke a necessary re-assessment of the effects of the rise of digital technologies, also in art practice. Galloway and others[19] point to how the content and events of digital media do not exist on-screen primarily by far, and thus largely happen beyond a straightforward, retinal view. Developing ways to see beyond the screen therefore seems one of the main goals of a post-digital analysis of art.

The merging of machine spaces and art practices asks for a visualisation method that is at the same time applicable to both science and art.

In his book *Visual Thinking* the psychologist and art theorist Rudolf Arnheim describes various forms of visualisation, one of which happens largely in the mind. It boils down to "seeing" things you know are there but which cannot or can barely be seen by the naked eye. It is not a form of imaginative construction of unreal events or phenomena. Arnheim speaks of "models for theory"[20]. He describes examples of how such models appear in nature sciences and geometry, especially in their early days. Even if he uses examples from the hard sciences, his approach of scientific visualisations is largely psychological[21]. He explains how every scientific model of an unseeable event or object is never static or stable, as it is based on a mixture of theory, observation, experience, and psychology. In other words, these visualisations are as much subjective as they are objective views of events, phenomena, or objects that exist beyond the reach of the human eye.

Arnheim gives an example of how psychological or cultural influences can affect visual thinking: Galileo not only had to battle church dogmas. He also had to constantly challenge his own, learned modes of perception, and in the end he did not completely succeed. Galileo refused to accept planets rotated around the sun in ellipses rather than in circles. His refusal was based on cultural notions of his day in which religious beliefs suggested an underlying perfection existing in all of God's creation. Ellipses were considered imperfect. Arnheim quotes Erwin Panofsky pointing out that the ellipse, the distorted circle, "was as emphatically rejected by High renaissance art as it was cherished in mannerism"[22]. Yet, even if Galileo's vision of how the earth moves through the universe was not entirely correct, his model of the universe did change our view of our planet radically, and gave the work of other scientists an important new direction. A shift of perspective can apparently enrich the way we approach things, even if not every detail of this new view is in line with the reality it reveals.

A visualisation such as meant in Arnheim's theory is flexible, and is not meant to prescribe how works of art should be interpreted or valued. Works of art can still be explored from different perspectives, for the development of which intuition, theory, and physical experience are combined. What a development of this form of visualisation may add is an experience of seemingly scattered or elusive works as relatively concrete, graspable objects or processes. In other words, rather than depending on a few visible markers the view of a work could entail shapes ungraspable by the eye alone, but deductible or knowable to the mind, to serve as the basis for a possible interpretation. According to Arnheim, "all shapes are experienced as patterns of forces and are relevant only as patterns of forces"[23]. In this sense an art object in a gallery and a networked installation are not that different. Pictures, models, or visualisations developed from interpreting these patterns of forces however depend on former experiences and intellectual, cultural, or emotional preconceptions of the beholder.

To illustrate how this can play out: whereas Jacques Ranci.re describes the future of the image and representation in terms of "machines of reproduction"[24], Galloway looks at the same surface and see what he calls *The Interface Effect*, which is an effect "of other things, and thus tells the story of the larger forces that engender them"[25]. One sees a copy and editing tool, the other a change of the forces beyond the screen that the images represent. Ranci.re's example reveals a limited perception of the digital as screen-based, while Galloway puts forward a view of the digital as a complex structure of forces obscured by a focus on the screen. These two divergent approaches of the digital each offer a radically different view. The first limits a view of the digital to what is directly visible, while the second firmly places the construction of the screen within larger systems and barely or non-visible practices. By breaking away from the screen Galloway seems closest to a post-digital approach.

IV. Applying visual thinking

Arnheim's notion of models of theory describes a general way in which the mind's eye can see things, and how this way of seeing can help us make sense of things or situations. Contemporary art contains a highly varied field of practices, ranging from visual to performance to conceptual, and the interdisciplinary practices and works produced between them. Not one model for theory will fit to grasp the shape of all individual works of art. In the context of digital technologies art shows the same variety of practices and forms[26]. Individual works and practices need an approach that enables a view of their specific form and/or process, a specificity Arnheim's concept of models for theory does not offer on its own. Arnheim himself uses examples from cosmogony, geometry, and physics to illustrate how these models work[27]. The notion of models of theory therefore describes a way of seeing that arises from various disciplines or practices in which direct, retinal views of specific forms or processes cannot occur, can only be established partially, or are not available yet.

Research on post-screen works and practices therefore needs to be a departure point from which to develop visualisations for these works and practices. Arnheim also describes boundaries to visual thinking. A mental image is not a photographic image of reality, but an approximate, subjective view of a form or event. The creation of models of thought is influenced by "the psychological tendency towards simplest structure"[28], or a combination of an intuition or deduction of the shape we envision and the shapes we are already familiar with. Models of thought can make the shape of objects, processes, and events beyond the line of sight easier to grasp, but they also tend to be simplified versions of these objects, processes, and events. A model for theory is nothing more than an attempt to see structure beyond the line of sight. Applying this type of visualisation to works of art therefore means balancing an attempt to be accurate with the reality of inherent failure. Still, an additional, visual layer to the way post-screen works and practices are approached already cannot harm us, but it can possibly help and enrich the way we see. A poetic use of code[29], a sculptural use of networks[30], and conceptualist practices[31] are examples that show the heterogeneity of art beyond the screen. I treat these for the moment as separate categories, but am aware of the interdisciplinary character of each work in these areas, and of the physical and conceptual overlaps between them. In the next three sub chapters I briefly describe each category, and I try to apply visual thinking to an example in each.

IV.I. Code Art

Various authors have described the deep entrenchment of code in culture and society, and its defining role in new systems of power[32]. Others have emphasised the generative aspect of code and its application in various art practices, and how code art at least partly escapes institutional realms[33]. These views from the media art and media theoretical field seem to conflict with the tendency among influential art critics and cultural theorists to see and discuss the main issues of the digital in terms of the screen. The intervention of the post-digital may help here. What is clear from all descriptions of code art is that it cannot be represented on a retinal plane in its entirety, or in its full capacity. Code as a written text, deep within a computer or presented on screen or paper, encompasses a potential activity that cannot be grasped from a literal reading or retinal observation of code as text or effect alone. To create a visualisation of a work of code art we could attempt to include the potential activity inherent to code. Visualising the work in full force would have to include movement through time and space, however minimal in the machine it runs on, as well as its relation to cultural, social, and political realms. Let us take a work like Jaromil's Forkbomb for example, a highly poetic and minimal string of code designed to replicate itself endlessly. When seeing it displayed as text, like it was painted on a wall at Transmediale 2012, we could admire the simple beauty of the string of signs. Awareness of it being a piece of executable code of a very specific kind, a fork bomb virus, however could lead us beyond this relatively simple visible dimension. We could imagine a proliferation of that string of code in the shape of maybe a family tree, much like the poetic experiments Florian Cramer describes[34], but constantly splitting, moving, growing. We could at the same time see the hard disc working away and filling up, its design standardised so as to allow indeterminate applications and thus also viruses, along the observations in Matthew Fuller's *Media Ecologies*[35].

We could wait to see how much time it takes for the computer it runs on to crash, placing it in the media archaeological domain described by Jussi Parikka[36]. We could also see a computer failing at being a productive machine in terms of expectations of what its economic, cultural, or political purpose is in ways Galloway describes[37]. A visualisation of *Forkbomb* in action could in this way give body to what first may have appeared as a predominantly conceptual work, by revealing its profound embedding and movement in the very physical structure that is a computer, and in the socio-technological landscape that stretches out around it.

IV.II. Sculpture and Performance in Digital Networks

The visualisation of how technological networks are made part of specific works of art requires an explicit visualisation of hardware as well as of the role of hardware in information flows. In network art installations hardware is essential, and most of it is far beyond sight. Any Internet connection for example quite easily runs halfway around the world[38]. The myriad of specific operations to realise an Internet connection happens almost entirely automated[39]. It runs across different national borders in ways largely beyond our control. Internet connections therefore are not neutral, straightforward couplings of machines. Yet Internet connections in works of art are mostly discussed in terms of technology, virtual spaces, and telepresence, and seldom in terms of the mixed physical and techno-political essence of the network, let alone in terms of a visualisation of it[40].

By making the Internet part of a decentralised installation or performance, happening at different places at once, a composition is created that involves the implementation of a shared, semi-public infrastructure. This implementation of the Net is time-based, because the network involvement only exists when the installation runs or a live performance takes place[41]. Though some works in this category involve smaller or private networks that are not online and have no significant political dimension, in my opinion the use of the semi-public space of the Internet as a key factor in a work deserves special attention due to its political and cultural sensitivity. A post-digital view of art could and should include a sobering view of the Internet as bringer of alleged freedom and progress by disclosing the reality of and behind its construction. The political dimension to the Internet also affects the art world. The possibilities for artists to represent themselves and have a direct connection to their audience online creates a challenge to the authority of critics, curators, gallerists, and art institutions[42]. In this sense the interests of artists and media activists seem to overlap. It must maybe be emphasised though that an inclusion of a view of the way the Internet is constructed, and how it functions within a work of art, need not be political per se. It could also be aesthetic or poetic, or a combination of all these.

Several authors have described the role of the Internet as a continuation of struggles over media access and the development of free media or of tactical media[43]. The vulnerability of the Internet as a space for free speech and collaboration across borders has led some artists to develop alternative networks. These sometimes unpractical and sometimes highly inventive alternative networks are works of art in themselves, and, though they are not connected to the larger Internet, through their sheer separation and rejection of the Internet they can be seen as political, activist art statements. Several works from artists that are part of Weise 7, a studio and artist collective from Berlin, could be described this way.

Netless for example, a work by Daniil Vasiliev, establishes an independent network through the attachment of wirelessly communicating data storage devices to public transport vehicles such as trams. Information exchange in this network happens through manual upload to one of the devices, and an automatic exchange between two devices when the trams they are attached to pass each other. The work's shape is defined through physical, semi-physical, and conceptual elements: the trams, wireless storage devices, and the computers and phones of the users; the wifi-signals moving separately and overlapping occasionally; and the explicit separation of the Internet. Though the work is dispersed, it is still delineated by the public transport infrastructure's reach, the capacity of the wireless devices, and the network of users and their individual computers. One could maybe say it has a tentacle-like shape, whereby the ends of each tentacle dissolve in the personal network and interests of each user. By envisioning the patterns of forces involved conceptually, spatially, and physically, a relatively comprehensive and less abstract view of this installation could possibly emerge, rather than from a description and an abstract presentation model alone.

IV.III. Conceptualism and the Digital Sphere

In the last few years a growing awareness of the influence of the Internet in art beyond the computer has evolved through the development of so-called Post-Internet art[44]. The Post-Internet art "movement" and the post-digital have in common that they both re-examine the faulty premises common views of digital culture are based on. They also seem to share a questioning of boundaries between technological and socio-cultural domains, in particular the penetration of life and culture by concepts and practices originating in the technological domain. The reason I call certain art practices conceptualist is that they largely manifest themselves in some form outside of digital media, yet these media do inform their shape. The technology seemingly disappears in them. Maybe more than in other art practices digital media here "remediate the very conditions of being itself"[45].

Works range from performance and activist art to sculpture, painting, video, and prints[46]. Works in this highly diverse group of practices seem to have three things in common: they use the Internet as an information or material resource; they use the Internet as a community space; and they use digital media for publication purposes[47]. The works in themselves largely take shape outside the computer. Some works, such as the activist art performances of the *Yes Men/rtmark*, are described in books about net art and digital art 48. More object-based work, like that associated with the "Post-Internet" label, still largely needs to find its way into literature. Marisa Olson describes the extensive use of found photography in Post-Internet practices in terms of a revaluation of "portraits of the Web". "Taken out of circulation and repurposed, they are ascribed with new value, like the shiny bars locked up in Fort Knox"[49].

To develop a model for theory or visualisation of the indirect effects of technology at play in conceptualist works of art could be difficult. Following Arnheim's view that these visualisations always take the simplest form, the elusive and near intangible echoes of technology in these particular conceptualist practices seem to ask for a highly abstract yet familiar model. One such model for an all-pervading yet invisible machine comes from the world of popular fiction. Borrowing from the Hollywood blockbuster *The Matrix* Vito Campanelli speaks of an "aesthetic matrix" when describing the influence of the design and content of the web. He sees our current cultural situation as "a time characterised by a diffuse aesthetics and by memetic transmission", especially pertaining to "cultural elements" such as images[50]. Next to media content one could however also include the subtle but defining role of tools and technologies in the development of practices in this aesthetic. The work of the Yes Men may serve as an example.

The art activism of the Yes Men consists largely of infiltration and subversion strategies. They copy the logo and communication design of a certain corporation or institution and use it as a facade for their intervention in the media presence of this corporation or institution[51]. The Yes Men's work is a juggling with the different dimensions of reality: the reality of physical space; the reality of media representations; and the specific historical and cultural perceptions relating to their target. They use the space between the reality of physical space and that of media representations as a theatre in which to perform alternative histories. This in-between space is a physical space, a technological space, and a conceptual space at once[52]. We could maybe see the shapes of individual works of art in this space as explicitly virtual, even if they appear as objects, like in Post-Internet art. The virtual, in the sense of representing the potential of an event or object, here exists in ghost-like shapes and processes that consist of the ectoplasm, the leakage, or the extra-digital results of digital technologies. An analysis of this leakage seems to belong in the techno-critical exploration the post-digital approach may offer.

V. Finally

In the twenty years I worked as a critic and observer of art in the context of digital technologies, I have been confronted with a partial but rather substantial blindness to the shapes of works and practices in this area in audiences, critics, educators, and curators. The relative inexperience with computers and related technologies seems to make it easy either to be sucked into, or to be turned away by, the movements and the glitter on the screen. Furthermore, a reluctance to see the screen in a different light seems informed by pre-digital cultural theory, in which cinema and television were the main focus of analysis[53]. I have tried to show how this surface view of the digital media is distracting and misleading.

New technologies have enabled artists to make structures and processes that are too large, too small, or too elusive for us to perceive with our eyes alone. The computer and its networks seem to especially influence this tendency. A screen-based view of art in this context will not make the works in question visible. Different descriptions and analyses of these works exist, but these are mostly based on a conceptual approach. A comprehensive visual approach to these works does not exist yet. In my search for a way to pass on my own experiences, in particular with art in networks, I stumbled upon Arnheim's *Visual Thinking*. In the chapter "Models for Theory", Arnheim describes a way of seeing in which the inner mind creates visualisations of complex or large phenomena[54]. These visualisations are part of the formation of a grasp of the shape and processes of these phenomena. Though Arnheim ascribes this visualisation technique for science, I think it can just as easily be applied to the arts. Here too we have complex and large structures the shape and processes of which almost completely escape the eye. By trying to develop a visualisation of a work from patterns of forces, or from those elements and effects of a work we can experience directly, it may be possible to get a more profound or full experience of a work as it expands beyond the line of sight. This visualisation technique is not to replace interpretation, but I offer it as a possible additional strategy to approach and experience specific works of art. Rather than approaching complex, unstable, and/ or very large or small works as limited or, on the contrary, as dissolving into an undefined public sphere or some mysterious machinic universe, it may be possible to discern shapes, trajectories, and spheres of influence or interaction. Arnheim's "models for theory" approach comes closest to my own view and experience of art in the context of digital technologies. To hopefully clarify, but also to inspire possible new visualisations in the reader, I have added examples of possible implementations of this particular form of visualisation, which no doubt should be refined.

"Post-digital is post-screen", the title of my paper, refers to the need to develop new approaches to art and culture in the context of digital technologies. Getting stuck in an endless loop of images and copied images is not how the arts of today need to be perceived. A post-digital perspective can help us see deeper, and further.

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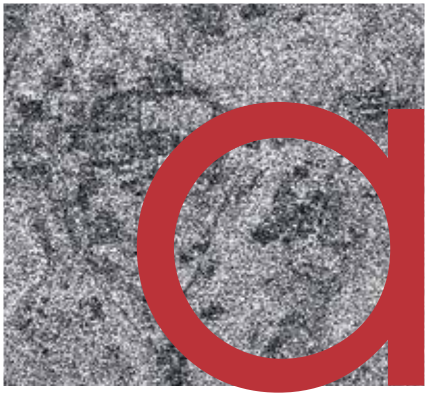


agency

Minds hacked by AI, free will made of silicon lightning, CRISPR promise of health, data gnosis, Nemo visioning zeros and ones, changing faculties, time redefined, inverted orders and crumbling identities, DNA-fiction, border-fiction, country-fiction, nationalist-fiction, virginal act start anew, history old rags, trickster mind in trickster data, what agency did you conquer?

Big Data is about the explosion of viewpoints, about rethinking what we thought we knew, science like art always different answers to known questions, treasure troves of data spilling into new visions, or like DNA rollercoasting into epigenetics then the agency of CRISPR, book of life coding and decoding your organs, who can stop the many dreams of correction, a makeable health coded and untwisting, each single suffering the immense responsibility of life, dizziness looking into mirrors mirroring the mind is everywhere and the environment is within, in us, intimate and fleeting. No more divisions of body and mind or mind and nature but nature within us and put to the test, Big Data linking time and history old as Greeks, history's starting point the big bang aeons of coding culminating in silicon is what you think really what you think or really what you want to think? So where's your Agency?

D.pulex Black Box

Retinitis Pigmentosa

IN|de|Finite

Conversation on Time

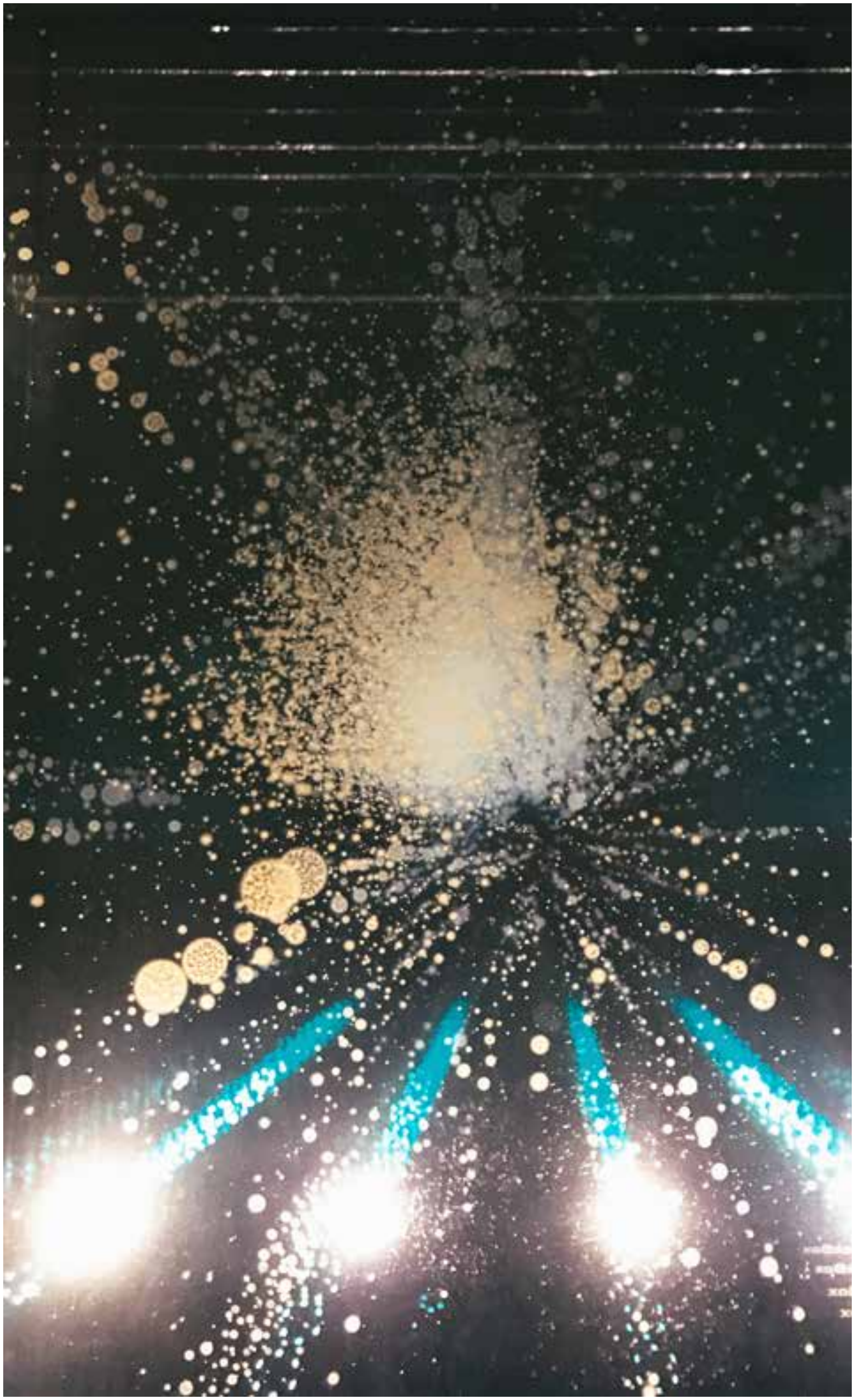
D.pulex Black Box

Artist
Nastassia Zenovich

Scientists
Laura Gribaldo
Mauro Petrillo

Collaborator
Jana Asselman, Ghent University

D.Pulex Black Box, 2019
Glass installation
Mixed media: glass, electronics, conductive paint,
plywood, plexiglass



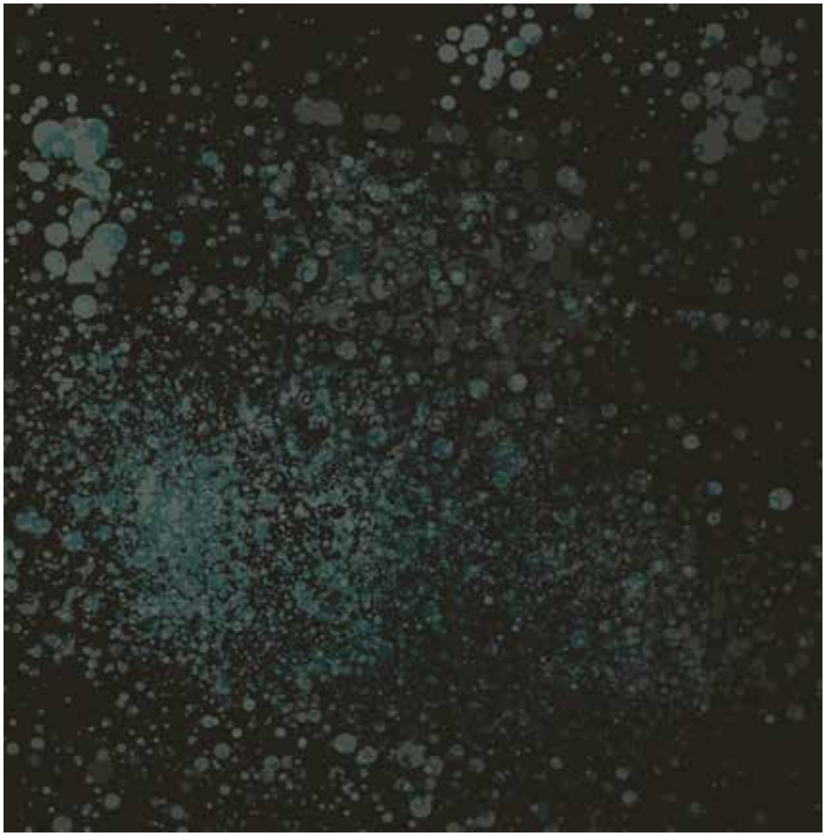
D.pulex Black Box,
Resonances III Datami
Festival JRC-Ispra site
15 October-8 November 2019
Installation view
Photo Nastassia Zenovich

I. Description of the work

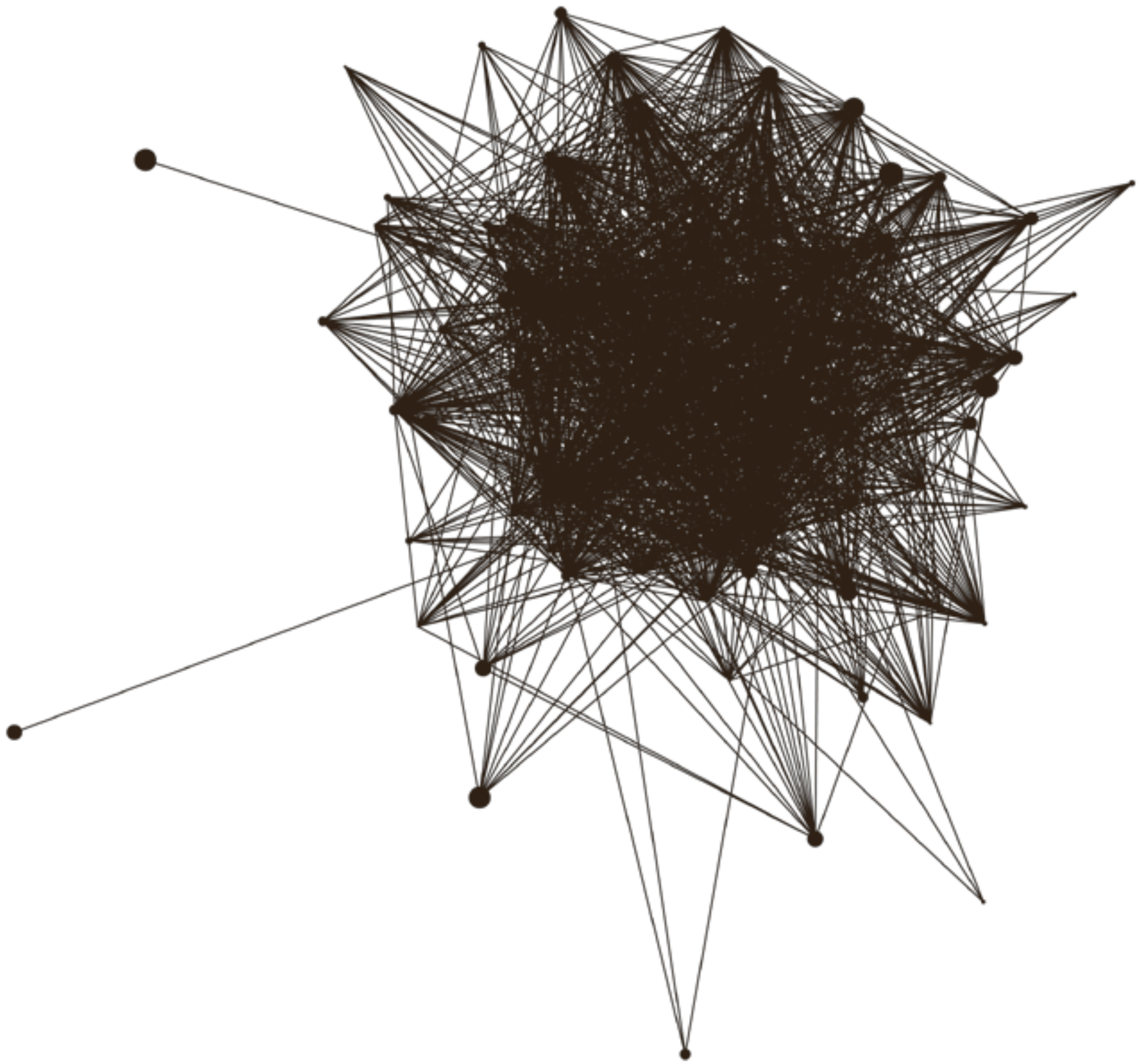
My work for the Resonances III Datami Festival is an interactive three-dimensional genetic installation, which explores gene expression networks of D.pulex (Daphnia pulex) in a concept of a Black Box — an unknown algorithm, which math could possibly someday describe and understand, by close observation and comparison of multiple data, effectively the Big Data of genetic information.

D.pulex is a very common species of the water flea, which is well-documented thanks to great eco-responsivity: its epigenetics (modifications of how and how much of the genes slumbering in DNA are read) reacts sensitively to environmental changes, climate, and the presence of natural predators. Each layer of the installation represents the uniqueness of each organism's epigenetic reaction to the environment, at the same time showing that the math of the whole system lies in between the layers and can be discovered only by collecting, comparing and analysing a massive set of these individual data.

On one side, the installation explores insights of biology, the natural science that studies life and living organisms with growing accuracy. On the other, its alive, completely non-static structures, deeply connected with time-based accidents, environmental factors, human personal inputs, stochastic changes, and the necessary evolutionary plasticity. It also explores systems biology and bioinformatics, emerging as modern interdisciplinary research fields, based on collecting and analysing large amounts of biological data, to understand the complexity of life in a larger picture. This includes human ones, which are sensitive and personal.

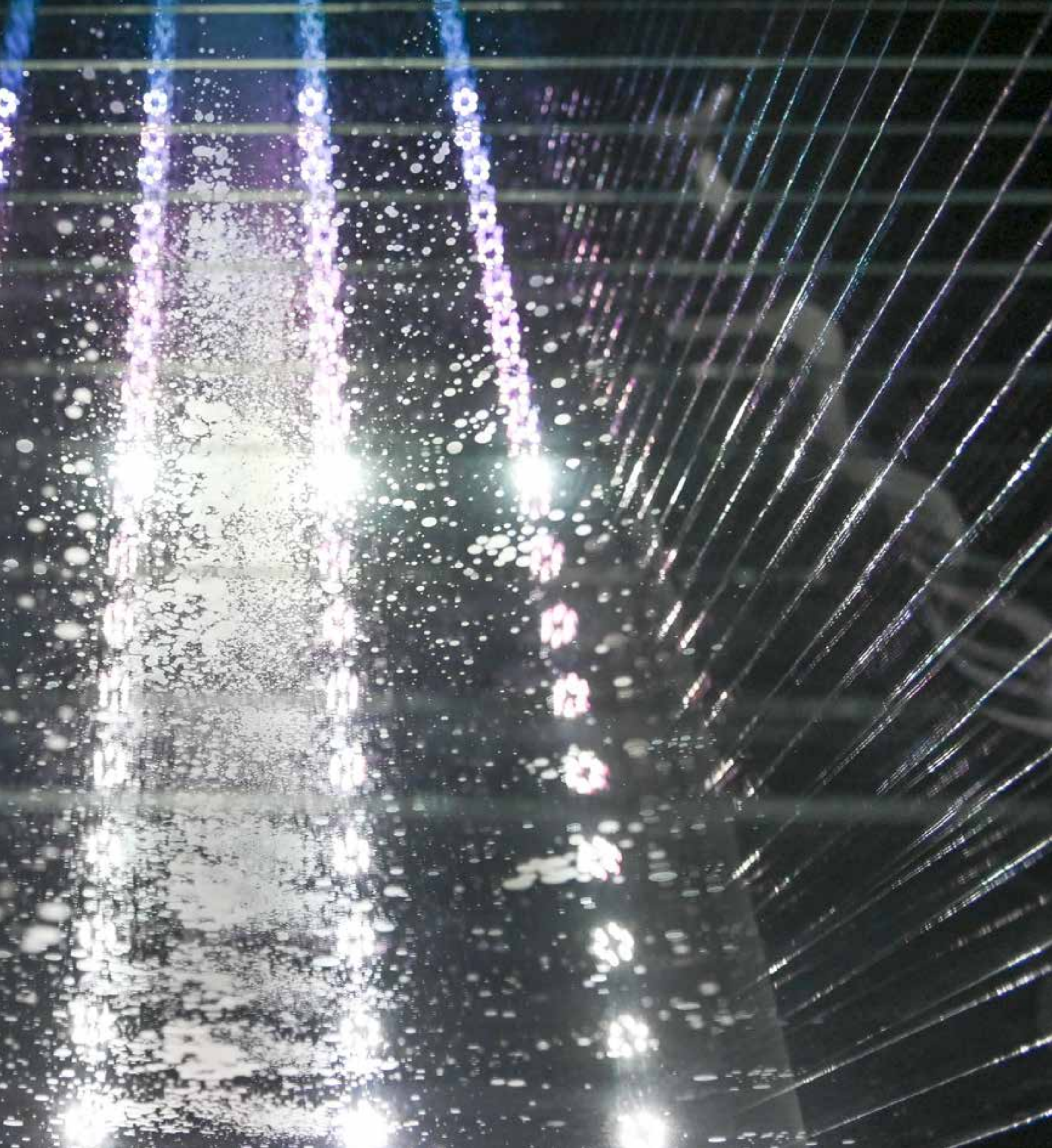


D. pulex Black Box,
Resonaces III Datami
Nastassia Zenovich,
part of layered *D.pulex*
graph visualization, 2019



D. pulex Black Box,
Resonaces III Datami
Nastassia Zenovich,
part of *D.pulex*
graph with edges visualization, 2019

D.pulex Black Box,
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Installation view
Photo Riccardo Pareggiani



Data Reference

The data visualisation of the installation is based on research of D.pulex environmental sensitivity and D.pulex gene coexpression networks[1] , and on cooperation with scientists Mauro Petrillo and Laura Gribaldo.

With data for the installation provided by J. Asselman from the Laboratory of Environmental Toxicology and Aquatic Ecology, at the Universiteit Ghent, Belgium, the network structure from the WGCNA analysis[2] was combined with the data of expression profiles. This enabled the reconstruction of the main process of scientific research, coupling it to the idea of DNA plasticity and individual organisms. To do so, multiple D.pulex profiles used in the research were reconstructed as separate visual layers with interactive response to a user's presence.

The water flea Daphnia pulex is a keystone species of freshwater ecosystems, where Daphnia-specific genes are the genes most responsive to ecological challenges[3] . Their populations are defined by the boundaries of ponds and lakes; they are sensitive to modern toxicants in the environment, and thus are used to assess the ecological impact of environmental change.

II. Excursus on Artist's vision

As a graphic designer and artist, I consider Big Data itself as a new starting point for humanity to understand itself in a newly emerging, fast, complex, and possibly biased reality. A way to expand existing knowledge and study society on a previously unavailable scale, unlocked by examining phenomena through the lens of massive amounts of raw and sometimes unforeseen data.

The concept of Datami here is a way to connect modern scientific visions and tools. These are sometimes quite distant from people's everyday practices, since human perception can trail the power of Big Data and, as humans, we are endangered in our unique position as intelligent beings, but with the hypothetical capacity to discover and train a new sensitivity for these data. I found Datami a perfect place to search for an artistic way to think about Big Data and their effects on our capacities of perception.

During the meeting with Professor John K. Colbourne on the JRC site in June 2019, somebody expressed the idea that science itself is not enough to bring change to society, medicine and economy, but that we really need a cultural change. And that's how I see the SciArt programme — as a connection tool between science and how it is perceived by people, as well as an occasion to draw on scientific results and explore multiple and growing datasets, hunting for new understanding.

Meetings brief notes

Based on the meetings with Mauro Petrillo and Laura Gribaldo, the concept of complexity and sensitivity of the data developed to form the basis of the installation. Big Data requires both an engagement and a basic understanding of the topic from the public, as well as fast policy development.

During the lecture and open discussion between Prof. John K. Colbourne from the School of Biosciences, University of Birmingham, and the community of the JRC Ispra science departments, several topics were discussed:

- Science itself might not be enough to quickly implement its results into society, and positively influence our economies and social development – what is needed first is a cultural change;
- Genes themselves, and especially their reactions to the surroundings, are conservative. They rarely change during evolution. In this way, the evolution of genes can prevail over the evolution of the species;
- The possibility of using genes study and biomarkers study of the 'simplest' model organisms, such as D.pulex, could in the future replace animal testing in medical industries.

All these points contributed to the creation of the conceptual basis of the installation: a living organism can be considered in a certain sense as a form-factor for

the development of gene evolution, where gene function evolution occurs prior to species evolution. This idea becomes valuable when considering the relationship between humans and other species, including the environment, and in light of new possibilities to study, use and control genes. The discussion on what humanity wants to control and what we're allowed to control, what changes we want to favour, and which ones we must prohibit, needs to be held urgently and as broadly as possible.

D.pulex Black Box,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view
Photo Amal Mokded

Notes

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Retinitis Pigmentosa

Artist
Maria McKinney

Scientists
Valentina Paracchini
Mauro Petrillo

Institutional Cooperations
Illumina Cambridge, UK/Science For Life Laboratory, Sweden/
The Francis Crick Institute, London, UK/Wellcome Trust Clinical Research Facility, University of Edinburgh, UK/Wellcome Sanger Institute, Cambridge, UK/Fondazione IRCCS Ca′ Granda Ospedale Maggiore Policlinico, Laboratorio di Genetica Medica, Milano, Italy/
Laboratorio di Genetica Molecolare, Bergamo, Italy/Neogen Europe, Scotland, UK/Oxford Genomics Centre, Wellcome Centre for Human Genetics, Oxford, UK/
Identigen, Dublin, Ireland/Max Planck Institute for Molecular Physiology

Retinitis Pigmentosa,
SciArt Datami project, 2019
Mixed Media: used flow cells and SNP chips, steel,
plastic, wire, ribbon, fixings
Variable dimensions

Retinitis Pigmentosa,
Resonances III Datami
Festival JRC-Ispra
15 October-8 November 2019
Installation view
Photo Maria McKinney

Retinitis Pigmentosa

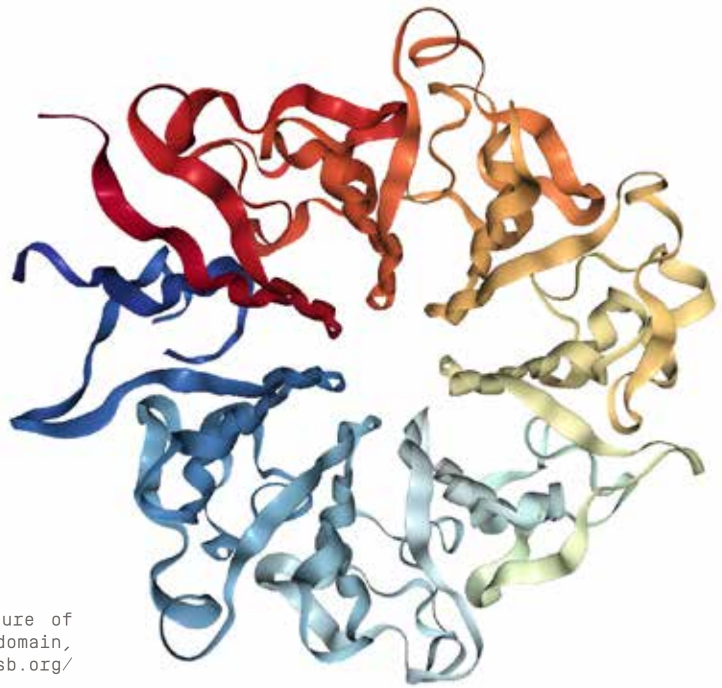
Maria McKinney

Together with genomic scientists Mauro Petrillo and Valentina Paracchini, our aim was to produce a work that considers the importance of sharing human genomic data. This is necessary in order to understand the mechanisms and the origin of rare genetic diseases and to find new treatments and possible cures for them.

We decided to explore this through the lens of the eye disease retinitis pigmentosa (RP), a group of rare genetic disorders that affect the light sensors in the eyes of the sufferer and causes loss of vision. Unfortunately, RP is incurable. A genome includes an intricately complex system of genes (humans have about 22,000 genes), which encode for an incredible number of products (mostly as proteins). Both genes and products, by performing their function and by interacting with each other through mechanisms which evolved over aeons, enable our biological bodies to function successfully. Scientists all over the world are working to decipher this most elaborate puzzle.

Understanding how a gene programs its proteins, interacts with its counterparts or malfunctions, necessitates sharing the knowledge gained by studying each of them. Furthermore, researchers are discovering more about how external environmental factors can directly influence how our genes express themselves. No individual or laboratory alone could begin to comprehend all there is to understand about genetics. It requires amalgamating all of the data at a collective level in order to understand what happens at an individual level.

To achieve this understanding, people from a variety of backgrounds and geographical locations must be willing to allow their genetic data to be shared amongst the scientific community. On 10th April 2018, thirteen European countries (nowadays 20) signed a declaration for delivering cross-border access to their genomic information: sharing more genomic data will improve understanding and prevention of diseases, allowing for more personalised treatments (and target-



4JHN The crystal structure of the RPGR RCC1-like domain, RCSB PDB, http://www.rcsb.org/structure/4JHN[1] ed drug prescription), in particular for rare diseases and cancer. The European Commission is supporting Member States in setting up a voluntary coordination mechanism of public authorities.

My own practice involves the selection of a particular material whose area of habitual function is the object of enquiry. When visiting the laboratories at JRC I encountered distinct forms of computer chips used in genetic research – flow cells, microarrays and DNA sequencing machines. Initially seduced by the way they refracted and reflected light, my interest in them furthered once I learned their purpose within genetic research. Functioning as vessels for DNA, they carry this biological material into the core of a computer system via a specialised scanner. Here, the genetic sequence is essentially read by computer software, and becomes part of the expanding global pool of data being generated in order to understand how genes operate.

These chips are a physical meeting point between the biological matter of DNA and digital technology. Beyond their task to carry genetic material, they also bear a symbolic load there is a great responsibility that comes along with deciphering this most fundamental and complex system of biological life.

The formation of the suspended installation is based on the crystal structure of the retinitis pigmentosa GTPase regulator (RPGR) protein, determined in 2013 [2]. This protein is encoded by a RPGR gene, which is located on the X chromosome. Its function is most probably in regulating cell cilia formation, hair-like sensory organelles found on almost all human cells. Mutations occurring at DNA levels result as alteration in the shape of the protein, which is not able to function as expected thus causing one of the most severe forms of retinitis pigmentosa.

Some of the mutations occurring on the RPGR gene affect not only eye vision, but also the respiratory and hearing systems, leading to chronic watery sputum with chronic cough, chronic sinusitis and sensorineural hearing loss.

Retinitis Pigmentosa,
Resonances III Datami
Festival JRC-Ispra site
15 October-8 November 2019
Installation view with Freddy Paul
Grunert and Paul Dujardin
Photo Siobhan McDonald

Notes

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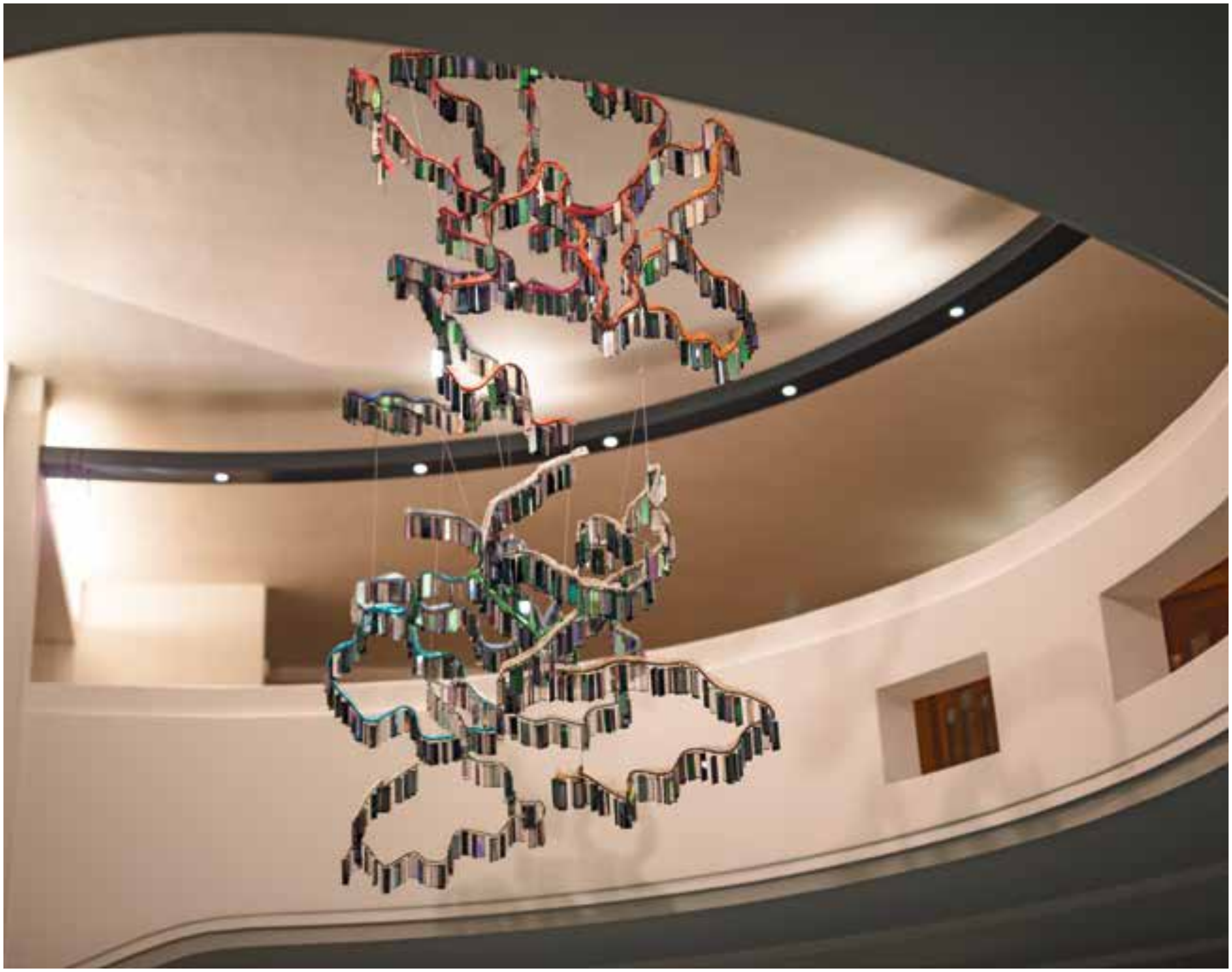
2. https://www.rcsb.org/structure/4JHN

Retinitis Pigmentosa,
Resonances III Datami
Bozar*,* Foyer*,*
Exhibition BozarLab*,* Brussels
10 December 2019 – 19 January 2020
Installation view
Photo Maria McKinney

Pictures on these pages
and on the next pages:
Retinitis Pigmentosa,
Resonances III Datami
Bozar, Foyer,
Exhibition BozarLab, Brussels
10 December 2019 – 19 January 2020
Installation views
Photo Maria McKinney



IN|de|Finite
[Never consider your mind
just as a mirror
of reality]

Artist
PRASQUAL

Scientists
Nicole Dewandre
Nikolaos Stilianakis

Collaborator
Cristina Fiordimela, Architect

Perfomers
Ken Konishi
Clara-Sophie Mügge
Marlyse Müller

IN|de|Finite,
[Never consider your mind just as a mirror of reality]
SciArt Datami project, 2019
Sound installation/Architectonic construction/Performance

IN|de|Finite,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view
during the performance
Photo Siobhan McDonald

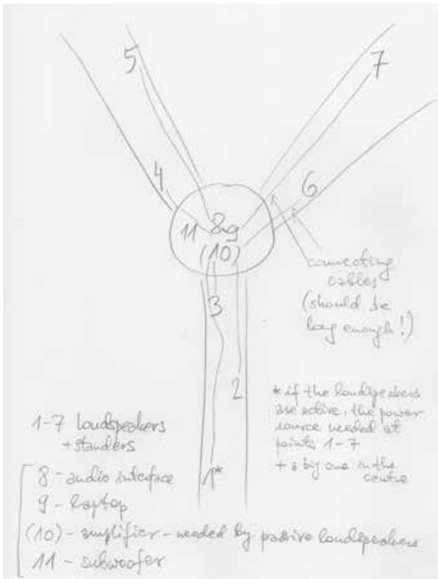
IN|de|Finite – Programme Note

IN|de|Finite (Never consider your mind just as a mirror of reality) is an installation for an architectural construction, seven loudspeakers and three performers in space. It takes a critical philosophical look on Big Data and its perspective of infinity.

What we would like to highlight in this work, is the new concept of *humanness with relationality and mutuality* at its core. We consider filtering as a new epistemological gesture of dealing with masses of information: managing saturation instead of accumulation or striving for more. The filter is present in sound, but also as a grid over the audience. This grid puts print into the skin of performers, but also into the mind of spectators. The time needed for impact is perceived as a pure form of duration. Rather than a journey over linear time. This creates an experience of an expanded perception of the present, offering a feeling that one can lay into the present, and shift us from a fast-paced moment to an enduring one.

Nicole Dewandre:
"It was a challenge to cooperate with PRASQUAL as I am much more comfortable with visions than sounds. Visions are to space what sounds are to time. To experience sound, you have to take the time: no shortcuts, no overview!

This SciArt cooperation led me to discover the importance of overcoming the sense of impatience, or urgency, too often mobilised in the public realm. Taking the time, being in the time. There is no way to step out of the time in the same way as there is always the possibility to step out of a given space, to move to another one. Our relation to space nurtures the feeling that we can be "in control", or on top of things. Our relation to time nurtures instead the feeling that being alive is only experienced from within our own bodies, and that time passes by inexorably, in a way that escapes and shapes us altogether. We need to pay more attention to time, and how to relate to it. Not only for our own lives, but also in politics. Taking the time, does not mean wasting it!



What does all this have to do with Datami, you might ask? Well, the temporal challenge brought about by the explosion of data and artificial intelligence around us is to protect our attention spheres. Human attention is bound by time. It is not only scarce but vulnerable. Protecting our ability to relate to each other without being interrupted and/or prompted by notifications or requests for consent, will soon fall in the remit of what we should come to see as a fundamental right."

PRASQUAL:
"When I met Nicole Dewandre, I was immediately struck and fascinated by the sharpness of her thinking and incorporating it in acting with reality. At the beginning of our cooperation, I must admit, I often did not understand what she meant, and it was a long process and a big challenge to capture her thoughts in their entirety and complexity. Her way of questioning my ideas and concepts, as well as my framing of reality, made me rethink and reflect on my work in a manner I have never done before. This fruitful cooperation goes much further than working on *IN|de|Finite* only. It has deeply changed my view on reality in general. To say it in Hannah Arendt's words – this intense exchange with Nicole transformed me from being a rational subject to a relational self. This also had an immense impact on my thinking about Datami as a concept of connecting the worlds of art, science and politics: both inside one another, just like a transition between them. For me, Datami can exist only through connection – through accepting borders, and through sharing the responsibility in a deep respect, that we cannot foresee and fully control how these worlds influence each other and how they transform. This is the magic of synergy in which 1+1 becomes 4 or even 7.

Datami is a body/mind/spirit-cloud, permeable, rhizome-like and agglutinative. It is an archive of individual and collective experiences of all artists, scientists and policy makers involved in the SciArt project. Finally, it is also the sum of the personal and transpersonal, of the conscious, subconscious, unconscious and over-conscious."

IN|de|Finite,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Study of the coreography
Installation views
during the performance
Photos PRASQUAL

Illustration on the previous page:
PRASQUAL, Performance sketch, 2019

IN|de|Finite
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view
during the performance
Photo Federico Gianoli

Conversation with PRASQUAL

Nikolaos Stilianakis
February, June 2018
Time in digital times.

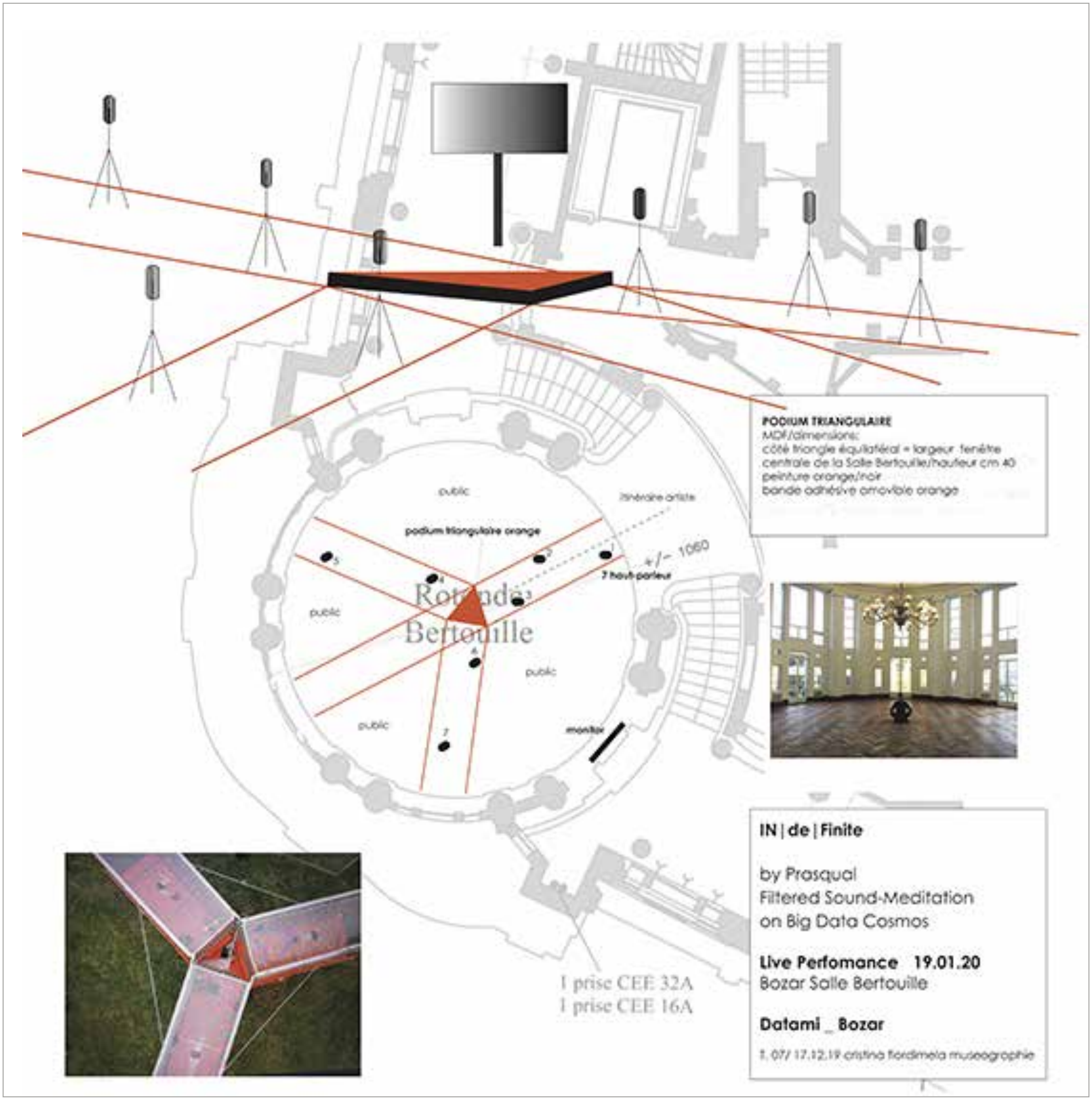
What do we get from Big Data? Everything and nothing at once. The more data the better? The content is irrelevant. The question of why has been re-placed by the question of what. That is what generates data. Data that can be used in another context. Attention has become a commodity. Network services compete for that.

How to react on this: Mindfulness. Stopping time for a moment. Thinking. Technological acceleration leads to a social synchronicity problem. Creativity is directly associated with time. The process of thinking in scientific research is a slow process that needs time for reflection. Leisure (in German *Muße*) is the key element. It creates conditions that allow for relaxed, reflective thinking and creativity.

This is currently missing. Science has been infected by societal developments related to speed and the notion that one needs fast decision making all the time. The economic processes in form of commercial use of data for consumption are pushing for that.

Unfortunately, this has captured the scientific activity too establishing an atmosphere of haste. Friedrich Nietzsche's: *Die Bildung wird täglich geringer, weil die Hast größer wird* (the education is decreasing as the hurry grows) is ignored today.

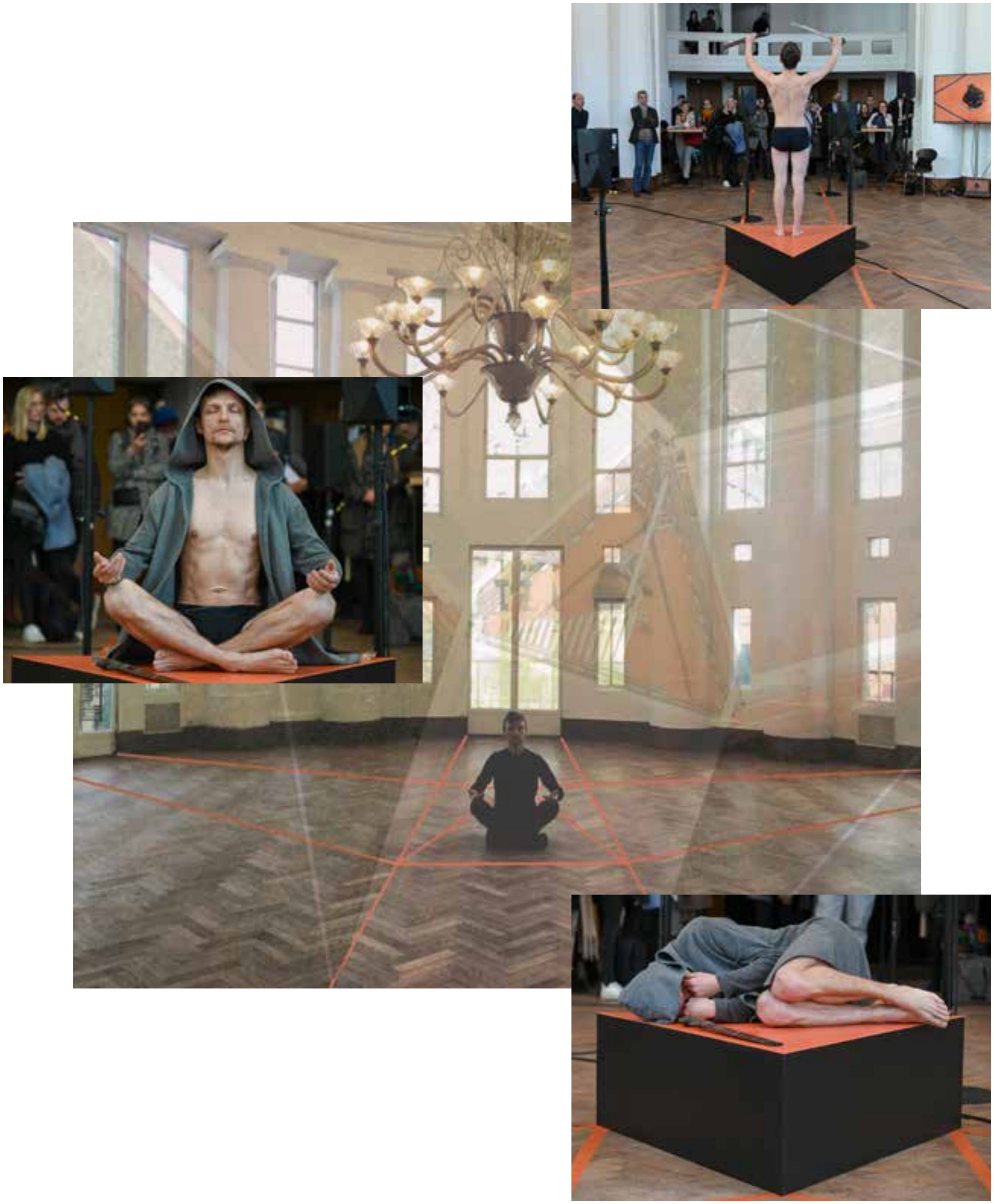
Creativity requires time and space.



IN|de|Finite,
Resonances III Datami
Exhibition BozarLab, Brussels
19 January 2020
Cristina Fiordimela,
layout of installation

IN|de|Finite is filtered meditation on the Cosmos of Big Data. It works with 33 sound layers composed in space and distributed by seven loudspeakers. The presence of performer symbolises development from an embryo/child into a meditating, spiritual human being. At the end the violence is taken out of the space.

IN|de|Finite,
Resonances III Datami
Exhibition BozarLab, Brussels
19 January 2020
Installation view during the performance
Photos Riccardo Pareggiani,
Cristina Fiordimela



Conversation on Time

Artist
Maria Rebecca Ballestra

Scientist
Nikolaos Stilianakis

Collaborators
Alessandro Olla, music
Mario Petrucci, poem and voice
Salvatore Rugolo, editing

Conversation on Time,
SciArt Datami project 2019
Video installation 10′ 45″

Conversation on Time,
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 – 19 January 2020
Installation view
Photo Riccardo Pareggiani

Our being is our being in time

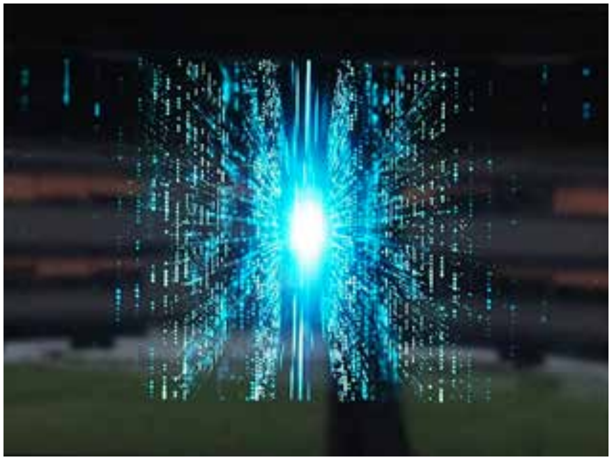
Maria Rebecca Ballestra

Big Data and associated new technologies are changing our way of communicating and perceiving reality. The flow of information and the mass sharing of ideas and acquaintances are changing our idea and perception of time and space. The concept of time in particular is one of the main paradigms for every society. It strongly influences the way we draw, shape and perceive our sojourn in the universe. Each culture has developed a different idea of time, and Big Data is creating a new sense of time in our contemporary society. We perceive the idea of time as a clear, fundamental and absolute concept, something simple, a uniform flow measured by clocks.

In reality, the nature of time is still one of the greatest mysteries of human perception. Research in quantum physics has taught us that there are many different forms of time, as every point in space has a different time. Internet, social media, Big Data, artificial intelligence, robotics and the overall technological revolution, are changing our sense of time. Paradoxically new technologies are developing an idea of time similar to the one suggested by quantum physics: a system of relation more than a system of things. “We can think of the world as constituted of things… Or think that the world is made up of events. Of processes. Of something that happens. Which does not last, which is continually transforming” (Carlo Rovelli, *L’ordine del tempo*, Adelphi, 2017)

This is exactly where new technologies are bringing us, by transforming the perception of the world around us from “a world of things” to “a world of processes”. Just like science, new technologies are transforming absolute parameters, like time, into fluid and relative parameters. Universal time has shattered into a myriad of proper times, like space has been shattered into a myriad of individual spaces and virtual community spaces. The acceleration of data production processes and data exchange brings the network system closer to that of neuronal processes, similarly to how the acceleration towards an absence of present is shaping a new concept of time.

It could be said that the model of universe, mind and processes of social interactions are overlapping thanks to a new idea of time, or rather, an absence of time. The installation *Conversation on Time* aims to invite visitors to reflect on the idea of time, and how our perception of reality has changed through Big Data and associated new technologies. The idea of time in science is compared with three Greek concepts of time (Chronos, Kairos, Aion). In a multi-screen projection, the installation aims at approaching the idea of time from three different perspectives: human time, earth time and the time of the universe. The installation contains a film about the concept of time for which artist Maria Rebecca Ballestra edited a poetic text, expressly created for the project by British poet Mario Petrucci, a Big Data visualisation, and a text by JRC scientist Nikolaos Stilianakis.



Conversation on Time,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation of view [detail]
Photo Cristina Fiordimela

Excerpts from a scientist's journal

Nikolaos Stilianakis

June 2018
Participation in the Science and Art workshop as a scientist yet only as arts layman. Topic 'Big Data', currently en vogue in science …and in arts. Invited artists come to Ispra. I am going to give a talk. My talk will be a provocation for main stream scientists in particular those who adore the topic and trust its potential blindly. To me it is a hype that won't meet expectations as many others in the past. I'll argue why following my intuition and insights, I have into the topic. Artists' expectations, unknown? Probably the unexpected.

Arts and Science

Scientists are trained to think in the frame of the scientific method; precise observations, measurements, exact calculations, test by experiment or controlled observations, make critical judgements, and ultimately reach an agreement on essential issues. Science is an evolving process of which the results are always temporary and subject to scrutiny. Scientific work may lead to vision narrowing and creativity shrinking. Due to its evolutionary character, science leads to many discussions, which often are a matter of opinion where critical judgment and perspectives, other than the scholars' view, may reach different conclusions, as well as open new ways of looking at things. Artists offer a different perspective, allowing scientists to put their work into perspective, review not only the purpose and ethics of their work, but also how they engage in communicating their work to the public. Arts may hereby resonate with a scientist's work.

Science is often very frustrating with long periods of hard work that may lead nowhere. Inspiration may therefore come from the collaboration with an artist, working on a piece of art together, potentially revealing different points of view. Creation is one thing, but here it may also be inspiring to look at a piece of art and the very interactions between scientists and artists in order to see how they approach the implementation of an idea. The diversity of perspectives one may have can substantially contribute to the understanding of the piece of research one works on. Arts may therefore help to expand scientific thinking.

The first discourse in this interaction of science and arts is always the influence of science on art or that of art on science. There are more in depth lying processes related to this interaction such as those of cognition, perception, intuition, psychological and physical structures, and the communicative and social action of images, not to forget the role of aesthetics, which is a shared instinct across arts and sciences. In mathematics, an area of treating highly complex structures full of cognitive abstraction, a mathematical problem may have several ways of proof. Mathematicians always distinguish between an aesthetically elegant proof and a simple proof. The dialogue between arts and science is palpable in structural intuitions that resonate from our mental and cognitive structures as well as from patterns of recognition in nature. Patterns of processes in nature are a typical example of structures intuited by artists and scientists alike. These aesthetics are also very powerful in communicating science. Thus, science and art can be full of intuitions shared by both scientists and artists, inspiring new scientific adventures and artistic horizons.

June 2018, SciArt workshop

Big Data. The current religion in science. Give me enough data and I'll explain the world. Everything goes. The more data the better. Is that true? What about data quality, purpose of collection, ability to answer the underlying question and finally causality?

My talk is about correlation versus causation. Are we observing a paradigm shift? I address the question of "why", arguing that it is ignored in the context of Big Data. If Big Data were only to be used as a marketing strategy, I would not mind. But it seems that it determines the dynamics of society and science, and this may have consequences. Can we really ignore the question of "why" something so fundamental in human thinking within science? Is the discovery of laws in science obsolete? Do we understand what we are doing? Is understanding desirable? Is pattern recognition based on correlations sufficient? At least it seems to suffice for quick decisions; these are the signs of the times. How many of these patterns lead to right decisions and how many are in fact wrong? How many of these are individual cases, and how many are generalisable? Nobody knows. Even worse: the question is not even stated. Speed is what counts. Is it our aspiration? Do we reduce everything to the economics of life? Is Immanuel Kant's exhortation to combine the specific with the general obsolete?

During the talk, I was worried whether the audience, in particular the artists, could follow my presentation.

Eye contact is there, yet I still cannot see the impact of my talk. I conclude and get good reactions and some interesting questions. During the break, several artists approach me. Very interested, they keep coming back again and again to the issue I addressed. I elaborate on it. They react, complement, question, dispute, agree, wonder. Several of them stay until the evening, talk with me and suggest some form of collaboration. The talk triggers their imagination and their intuition. Relief and surprise to me. Relief that I got their attention and they obviously could follow me. Surprise, that so many of them with so different backgrounds expressed interest in collaboration. It was a simple talk but obviously not simplistic.

SciArt workshop 2018. The days after the talk.

The days after the workshop are full of interactions with the artists, mainly in writing. The interactions resulted in collaborations with Maria Rebecca Ballestra, visual artist based in Monaco; Henry Fair photographer and environmental activist based in New York; Prasqual (Tomasz Praszczalek), musician and artist, based in Germany; Richard Pettifer, artist based in Berlin and Nicolas Strappini, science artist based in London. With all of them, I worked in the development of artistic ideas and proposed projects such as artistic videos about time and epidemics, photography concepts, music compositions and even an opera. All to explore the topic of Big Data through different perspectives.

September 2018

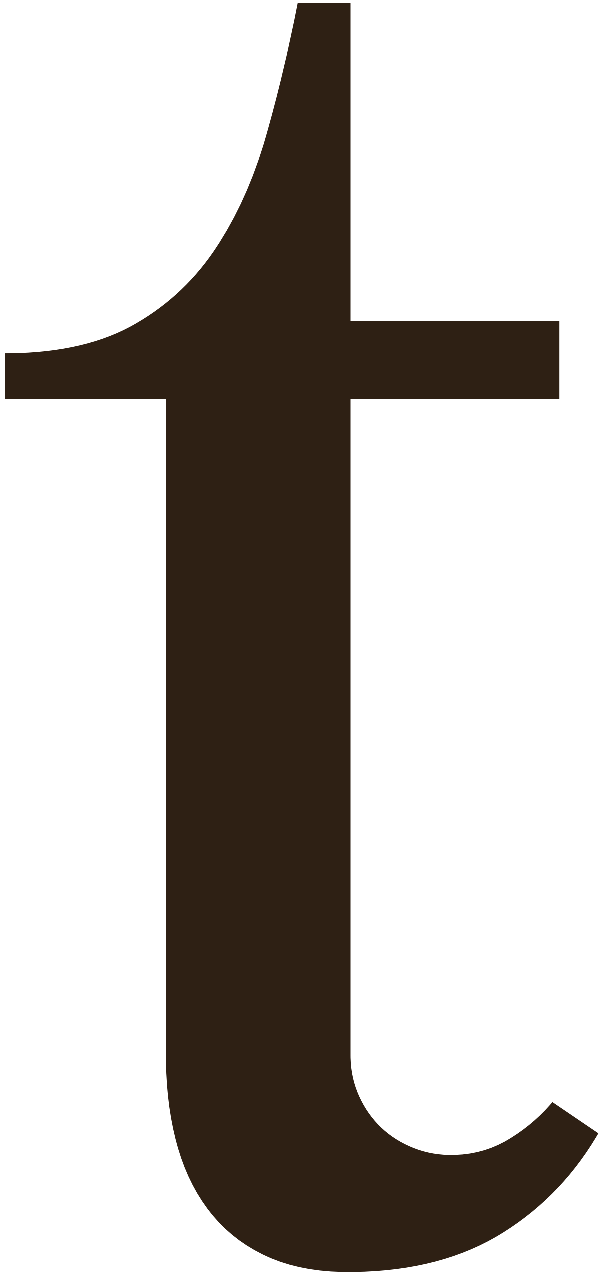
Three of the concepts, developed by the artists and myself, were selected for the Resonances III Festival.

A video installation on the notion of *time*, a concept developed with Maria Rebecca Ballestra. A performance piece, and music, developed with Prasqual. And an opera piece developed by Richard Pettifer, *My Data and me: una storia d'amore*. All of these projects were the result of an intensive process of exchange of ideas, impressions, expressions, thoughts, insights, foresights, conceptual sketches…

The period September 2018 to July 2019

I am in Brussels working for the Chief Scientific Advisors of the European Commission. Rebecca and Prasqual visited me twice to discuss their projects after some intensive e-mail interactions, while Richard and I kept on mostly staying in touch via e-mails. Long discussions with Rebecca on the concept of time often lead to other more fundamental issues such as questions of "why" and its role in scientific research, or the lack of time in thinking and its implication for science today. We linked the concept to Big Data. Rebecca explained to me how the ideas we had discussed could be visualised. A fantastic person full of energy and great intuition.

Extensive exchange and long discussions with Prasqual on the development of his music and performance piece. Discussions, almost exhaustive, trying to frame and merge our thoughts around the Big Data topic. I hope this will be a success.



The letter '**t**' represents
the time element in a four
dimensional space-time in the
formal representation of
Einstein's relativity theory

Discussion excerpts

February, April 2018.
Meetings with Maria Rebecca Ballestra
Time in history of science

One may delineate time in three scales in history of science. Every time scale has its own pace and every time scale has the potential to transform science. They are often interwoven. The first time scale runs in weeks or months and can be considered analogue to the ancient Greek term - *chronos* - time.

This is the fastest time scale and is that of empirical discovery and decision making. It comprises new scientific research results published regularly in scientific journals today, next week, next month. In recent years, scientific work has displayed some striking characteristics, such as the enormous amount of knowledge production, the type of knowledge produced, and the speed at which this knowledge is being published. The amount of knowledge is associated with the high number of scientists engaged in scientific research today on a global scale. The speed of publication is associated with the standards of qualification that hold today, to allow for researchers to pursue academic careers, as the amount of publications is seen as an essential asset and criterion for assessing his/her work. An ill development that causes many problems for science (acceleration is a sign of our times. Fast data production has its dominant place in this development). Finally, the most interesting thing is what is happening with the type of knowledge produced in science. The type of knowledge is typically a small piece of a potentially larger piece of work. The former is difficult to assess in its quality and potential since it is a small fragment (fragmentation too is a sign of our times). As to the latter nobody knows if, and when, it will appear in a complete comprehensive form as a rounded answer to a scientific question.

The emergence of the so-called Big Data and the newly named scientific object of data science has transformed the way society perceives science and how science defines itself. It has been the idea of the moment. The dramatic increase of computational capacity has led to the notion that it is all in the data. The proponents claim that data-driven scientific research represents a new scientific method and that it is the future of science. Enormous amounts of data can be calculated with automated algorithms and a breath-taking pace. In some scientific areas such as image processing this has led to impressive advancements. For other areas it remains to be shown whether the slogan “the more data the better” holds. The claim is that data is self-explanatory and data handling is more or less straightforward.

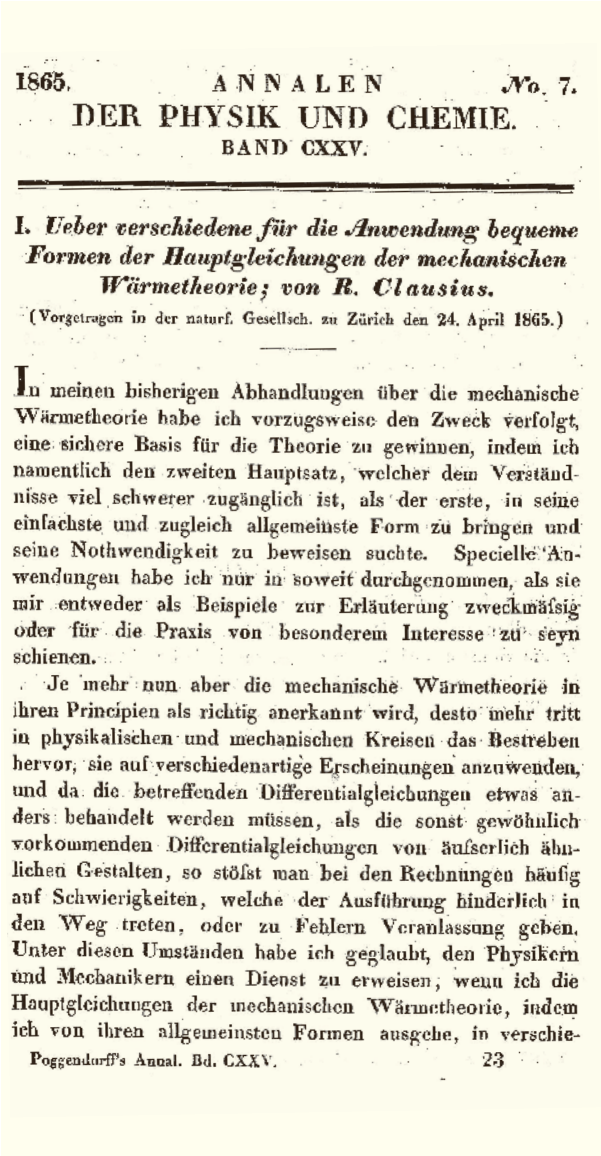
What type of data are generated and what type of results are produced though? Knowledge will depend on the increasing amount of data and computational capacity. In this case, knowledge is based on statistical associations rather than scientific hypotheses and their testing. Societal developments call for fast solutions and ‘Big Data’ offer a way to provide solutions, of which the nature and quality seems to be of no primary relevance. In other words, there is no time for fundamental research, no time for deep explanatory thinking since theory doesn’t matter. Is that what we want? The second time scale runs in periods of years and decades and can be considered an analogue to the ancient Greek term of *kairos*.

This is the time scale in science where frameworks of empirical research are developed. It is the period where cumulative empirical knowledge leads to shaping of scientific theories to explain those empirical discoveries; where different questions are embedded within a theory; where the search of explanations and scientific laws take place. This time scale is characterised by major theoretical frameworks such as those developed by Galileo, Newton, Einstein, Darwin, Watson and Crick. These theoretical frameworks have something in common.

They try to identify what we should look for. In other words, they try to answer the question of “why”. This fundamental inertial drive in science was already mentioned in ancient Greek philosophy. Aristotle and Plato claim that to know the “what” or “how” is very different from knowing the "why". Real knowledge is the knowledge of the causes and reasons of something. This principle governs theories and although theories may be overthrown and replaced, yet some other remain: a pivotal feature of scientific progress is that these theories have given us unprecedented insights into nature and in our understanding of the world. The answer of the question "why" is indeed a fundamental element of scientific theories.

Today's 'Big Data' claim is related to the "what" and ignores the "why". Data science methodologies may be able to form a prediction about the future based on statistical approaches but they cannot provide a causal explanation about the way the world works. Their contribution resides more in velocity in making things run faster and solving problems of speed and identification of patterns. This is however only a part of the full picture in understanding a process. Their employment will facilitate the solution of many societal problems. However, faster does not necessarily mean better quality, nor a better understanding or an understanding at all. Moreover, this new kind of science creates the notion that theories and explanations are redundant, challenging epistemological thinking. This has consequences.

One direct consequence in association with the notion of time is that scientists today do not have time to think. Major theories were developed over decades. The people behind them had time to think and reflect. It took Charles Darwin more than 20 years of hard thinking to develop his theory. He took at least one long walk every day. He called his route, "thinking path". He allowed his mind to wander. Friedrich Nietzsche used to walk for hours, often around lakes or up mountains. In Sorrento, Italy, he wandered to what he called his *Gedankenbaum* (tree of thoughts). Another essential ingredient of creativity directly associated with time to think in scientific research is leisure (in German *Muße*). It creates conditions that allow for relaxed, reflective thinking and creativity. Creativity requires time and space. The third time scale runs in periods of centuries or even millennia and can be considered an analogue to the ancient Greek term of



1865. ANNALEN No. 7.
DER PHYSIK UND CHEMIE.
BAND CXXV.

I. *Ueber verschiedene für die Anwendung bequeme Formen der Hauptgleichungen der mechanischen Wärmetheorie; von R. Clausius.*

(Vorgetragen in der naturf. Gesellsch. zu Zürich den 24. April 1865.)

In meinen bisherigen Abhandlungen über die mechanische Wärmetheorie habe ich vorzugsweise den Zweck verfolgt, eine sichere Basis für die Theorie zu gewinnen, indem ich namentlich den zweiten Hauptsatz, welcher dem Verständnisse viel schwerer zugänglich ist, als der erste, in seine einfachste und zugleich allgemeinste Form zu bringen und seine Nothwendigkeit zu beweisen suchte. Specielle Anwendungen habe ich nur in soweit durchgenommen, als sie mir entweder als Beispiele zur Erläuterung zweckmäſsig oder für die Praxis von besonderem Interesse zu seyn schienen.

Je mehr nun aber die mechanische Wärmetheorie in ihren Principien als richtig anerkannt wird, desto mehr tritt in physikalischen und mechanischen Kreisen das Bestreben hervor, sie auf verschiedenartige Erscheinungen anzuwenden, und da die betreffenden Differentialgleichungen etwas anders behandelt werden müssen, als die sonst gewöhnlich vorkommenden Differentialgleichungen von äuſserlich ähnlichen Gestalten, so stöſst man bei den Rechnungen häufig auf Schwierigkeiten, welche der Ausführung hinderlich in den Weg treten, oder zu Fehlern Veranlassung geben. Unter diesen Umständen habe ich geglaubt, den Physikern und Mechanikern einen Dienst zu erweisen, wenn ich die Hauptgleichungen der mechanischen Wärmetheorie, indem ich von ihren allgemeinsten Formen ausgehe, in verschie-

Poggendorff's Annal. Bd. CXXV. 23

aion. This time scale measures and accounts for the fundamental epistemic virtues of science.

It is about certainty, truth, precision, objectivity, coherence. All of these virtues are clearly visible in scientific practice and have been aspirations of science for centuries, nevertheless, with differences over places and periods. This extremely long time scale does not necessarily refer to knowledge, inclination or belief; but it could, given the overlapping nature of the three time scales. This time scale addresses long-lived scientific areas such as astronomy with the study of the stars, geology with the formation of the earth, demography looking at the population development, climatology with the observation and the evolution of global climate, or archaeology with development of human activity and civilisation. These sciences depend on long-lived collections of data. In all these fields, there have been systematic and structured collections of data that evolved and improved in quality and quantity as the scientific field grew over centuries, according to the standards of those epochs (as opposed to today's unstructured big data).

These long-lived data may last as long as humanity or even longer and remind us that scientific progress does not know an end. We know that modern sciences, at least the natural sciences, place predictive accuracy at the zenith of their pyramid of epistemic goals. This was not the case in the past. Certainty used to be the most important condition in science from antiquity up until the end of the seventeenth century. *Episteme* in Greek, *Scientia* in Latin. The concept of science was defined as certain knowledge according to facts which could be proven by axiomata in the same way as mathematical proofs. Later on, Isaac Newton called his laws of motions axiomata sive leges motus. The foremost aspiration for natural philosophy was certain universal knowledge. Predictive accuracy would certainly play also a role but it was not the top. It took time to develop the concept of science as probable and even revised knowledge – a slow but revolutionary transformation. Explanatory depth has been of fundamental importance and has been manifested in scientific laws and theories.

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anderer Zustände wieder in den Anfangszustand zurückgelangt, so mufs der unter dem Integralzeichen stehende Ausdruck $\frac{dQ}{T}$ das vollständige Differential einer Gröfse seyn, welche nur vom augenblicklich stattfindenden Zustande des Körpers, und nicht von dem Wege, auf welchem er in denselben gelangt ist, abhängt. Bezeichnen wir diese Gröfse mit S, so können wir setzen:

$$(59) \quad dS = \frac{dQ}{T},$$

oder, wenn wir uns diese Gleichung für irgend einen umkehrbaren Vorgang, durch welchen der Körper aus dem gewählten Anfangszustande in seinen gegenwärtigen Zustand gelangen kann, integrirt denken, und dabei den Werth, welchen die Gröfse S im Anfangszustande hat, mit S_0 bezeichnen:

$$(60) \quad S = S_0 + \int \frac{dQ}{T}.$$

Diese Gleichung ist in ganz analoger Weise zur Bestimmung von S anzuwenden, wie die Gleichung (58) zur Bestimmung von U.

Die physikalische Bedeutung der Gröfse S ist in meiner Abhandlung »über die Anwendung des Satzes von der Aequivalenz der Verwandlungen auf die innere Arbeit« des Näheren besprochen. Die in dieser Abhandlung unter (II.) gegebene Fundamentalgleichung, welche für alle in umkehrbarer Weise stattfindende Zustandsänderungen eines Körpers gilt, lautet, wenn man in der Bezeichnung die kleine Aenderung macht, dafs man nicht die von dem veränderlichen Körper nach aufsen abgegebene Wärme, sondern vielmehr die von ihm aufgenommene Wärme als positiv rechnet, folgendermaafsen:

$$(61) \quad \int \frac{dQ}{T} = \int \frac{dH}{T} + \int dZ.$$

Die beiden hierin an der rechten Seite stehenden Integrale sind die auf den vorliegenden Fall bezüglichen Werthe zweier in jener Abhandlung neu eingeführter Gröfsen.

25 *

Excerpts from Rudolf Clausius's work who first introduced the term entropy [in the original scientific paper in German] in 1865 and thus the idea of the 'arrow of time'. Equations 60 and 64 are equivalent. On page 390 the term entropy is mentioned for the first time in science'.
Clausius, R. [1865][1]

Today due to the emergence of the 'Big Data' concept, we observe two developments. We still have the pursuit for deep explanation of processes and phenomena. At the same time predictive accuracy is just as essential, sincethe ability to collect larger amounts of data led to better accuracy in prediction using statistical models. Statistical approaches are clearly agnostic about the causes. These types of approaches are heavily used in order to analyse 'Big Data', and one should be aware of the fact that these types of approaches do not allow for causation. In most scientific areas, they mainly address classification and correlation issues. The epistemic aspiration of 'Big Data' is predictive accuracy. This accounts for structured big data. What the epistemic aspiration of unstructured 'Big Data' might be, is unknown. Whatever it is, one is certain that their proponents promise more than they can deliver.

Gödel remarks that in his universe this situation is typical: for every possible definition of an "objective" time one could travel into regions which are past according to that definition. He continues:

> *This again shows that to assume an objective lapse of time would lose every justification in these worlds. For, in whatever way one may assume time to be lapsing, there will always exist possible observers to whose experienced lapse of time no objective lapse corresponds… But if the experience of the lapse of time can exist without an objective lapse of time, no reason can be given why an objective lapse of time should be assumed at all.*[2]

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so erhält man die Gleichung:

$$(64)\quad \int \frac{dQ}{T} = S - S_0,$$

welche, nur etwas anders geordnet, dieselbe ist, wie die unter (60) angeführte zur Bestimmung von S dienende Gleichung.

Sucht man für S einen bezeichnenden Namen, so könnte man, ähnlich wie von der Gröſse U gesagt ist, sie sey der *Wärme- und Werkinhalt* des Körpers, von der Gröſse S sagen, sie sey der *Verwandlungsinhalt* des Körpers. Da ich es aber für besser halte, die Namen derartiger für die Wissenschaft wichtiger Gröſsen aus den alten Sprachen zu entnehmen, damit sie unverändert in allen neuen Sprachen angewandt werden können, so schlage ich vor, die Gröſse S nach dem griechischen Worte ἡ τροπή, die Verwandlung, die *Entropie* des Körpers zu nennen. Das Wort *Entropie* habe ich absichtlich dem Worte *Energie* möglichst ähnlich gebildet, denn die beiden Gröſsen, welche durch diese Worte benannt werden sollen, sind ihren physikalischen Bedeutungen nach einander so nahe verwandt, daſs eine gewisse Gleichartigkeit in der Benennung mir zweckmäſsig zu seyn scheint.

Fassen wir, bevor wir weiter gehen, der Uebersichtlichkeit wegen noch einmal die verschiedenen im Verlaufe der Abhandlung besprochenen Gröſsen zusammen, welche durch die mechanische Wärmetheorie entweder neu eingeführt sind, oder doch eine veränderte Bedeutung erhalten haben, und welche sich alle darin gleich verhalten, daſs sie durch den augenblicklich stattfindenden Zustand des Körpers bestimmt sind, ohne daſs man die Art, wie der Körper in denselben gelangt ist, zu kennen braucht, so sind es folgende sechs: 1) der *Wärmeinhalt*, 2) der *Werkinhalt*, 3) die Summe der beiden vorigen, also der *Wärme- und Werkinhalt* oder die *Energie*; 4) der *Verwandlungswerth des Wärmeinhaltes*, 5) die *Disgregation*, welche als der Verwandlungswerth der stattfindenden Anordnung der Bestandtheile zu

Notes

1. "Über verschiedene für die Anwend-ung bequeme Formen der Haupt-gleichungen der mechanischen Wärmetheorie", Annalen der Physik, 125 [7]: 353–400.
2. John L. Bell, Time and Causation in Gödel's Universe, *Transcendent Philosophy*, 2:341.[2002]

Defining AI Arts: Three Proposals

Lev Manovich

Defining AI Arts: Three Proposals

I.

On first sight, coming up with a definition for "AI arts" does not sound hard. AI (an abbreviation for the term Artificial Intelligence) refers to computers being able to perform many human-like cognitive tasks, such as playing games of chess and Go, recognising content in images, translating between languages, selecting best candidates in a job search based on their CV's, and so on. This is how AI has been traditionally understood, and we can extend this concept to the arts. Following this logic, "AI arts" would refer *to humans programing computers to create with a significant degree of autonomy new artifacts or experiences that professional members of the art world would recognise as belonging to "contemporary art." Or, we can teach computers skills of artists from some earlier historical period and expect that professional art historians recognise new artifacts the computer creates as possible art from this period.* (In one study, computer scientists asked art historians to evaluate images generated by a neural network to simulate styles of particular artists.)[1]

In fact, we can extend the famous Turing test2 to AI arts - if art historians mistake objects that a computer creates after training for the original artifacts from some period, and if these objects are not simply slightly modified copies of existing artifacts, then, such a computer passed the "Turing AI Arts" test. This sounds simple and logical. Let's refer to this idea as our first proposal for the definition of "AI arts." In this definition, art created by an AI is something that professionals recognise as valid historical art or contemporary art.

Unfortunately, this logical approach is not sufficient. In fact, on closer inspection, its clarity dissolves. For example, there is no commonly accepted definition of "art" today among the professionals such as art critics, art theorists, philosophers of art, or sociologists of culture. So how can we program a computer to independently create something which we can't even define?

The development of modern art during the 20th century involved systematic questioning of the boundaries of what counts as art, and then going outside these boundaries - from Marcel Duchamp's ready-mades to happenings, performances, land works, and installations of the 1960's, to Internet art of the 1990's. But to understand what things can expand the boundaries of what counts as “art” at a given moment in a meaningful way requires knowledge of art history and development of the arts until the present - and this is something nobody so far tried to program into a computer.

Instead, most of the attempts to use AI techniques in the arts relied on (usually implicit) understanding of “art” that was relevant before the second modernist revolution of the 1950’s-1960’s (if we count 1880’s-1920’s as the first revolution). In other words, the artists, writers, composers and computer scientists taught computers to create objects in the formats that were accepted as art among the modern people up to the. late 1950’s - single images, poems, music compositions. (By a strange coincidence, these experiments in AI arts begun at the same time as modern art enters its second revolution period, i.e. late 1950’s. So, while some artists move beyond art as it existed up until that time, other artists start programming computers to create “traditional art,” i.e. objects rather than processes, situations, and performances.)

This tendency is still with us. If we look at what has been recently (2015-) celebrated as achievements of AI in visual arts, these are often single images that look like modernist paintings. They may deliberately simulate visual appearance of some well-known modern artist, or simply look like some variations of expressionism, cubism, post-impressionism, etc.

If we follow this conservative tendency, we have to accept that “AI arts” only simu-late the historical art. It is not capable of executing the main strategy of modern art - constantly expanding what counts as art. (Note that interactive computer installation, the genre that developed in the 1990’s, is one important exception). Of course, it is also possible to argue that in the early 21st century this. strategy of expanding art lost its energy, we entered the period of pluralism, and creation of the “new” is no longer relevant. Still, this does not invalidate my main point - what has entered history as the achievements of “AI Arts” during the last six decades represents simulations of historical art created before this AI arts work starts.

II.

Let’s try another approach. Instead of thinking about the outputs of an “art computer,” let’s consider the process of creation. Given that computers have been used in the arts in lots of ways for six decades, is there something unique about “AI arts”? Is it possible to make a clear distinction between “computer arts” (or “digital arts”) and “AI arts”?

One of the most popular methods for using computers in the arts and design is writing computer programs that generate objects in various media (text, image, video, 3D shapes, graphic designs, logos, urban plans, music, etc). Such programs can take a variety of forms - simple instructions to draw a sequence of shapes, algorithms that generate fractals, cellular automata algorithms, genetic algorithms (Karl Sims), and so on. For example, the pioneering computer artists of the 1960's - Vera Moln.r, Desmond Paul Henry, Frieder Nake, Georg Nees, Michael Noll, Sonia Sheridan, and others - wrote programs that gen rated geometric black and white patterns using precise instructions, while also sometimes incorporating random parameters. In design and architecture worlds, use of algorithms is often called "procedural," "generative," or "parametric" design. This approach to design is widely used today in all design fields and it is responsible for some of the most famous cultural creations of our times such as works by Zaha Hadid Architects.

Is there some fundamental distinction between such methods of computer arts that have been used for decades, and another paradigm that became very popular in the 2010's - use of "machine learning" and deep neural networks? Note that AI field includes many approaches developed since the 1950's. Machine learning and neural networks are only two among them. They became dominant in the industry in the 2010's.

The neural networks paradigm includes a number of methods and some of them were adopted for generation of cultural artifacts. In one approach, the single network is trained using a large set of examples such as images in one style. Following the training, the network can generate more images in the same style.

In another approach called GAN (Generative Adversarial Network), generation of new artifacts involves two networks. One trained on a set of example creates new artifacts. These artifacts are evaluated by a second network and it selects the ones that are similar to the training examples. In yet another approach called "style transfer," the network learns how to transfer a style from a single or a series of images to new images (or video) - for example, transferring a "style" of one Van Gogh's painting to a photograph[3]. (I think that this approach has a conceptual problem, because an artist such as Van Gogh does not have a "style" - i.e. a form that exists independently from the works' content. The particular transformations of visible world we see in Van Gogh paintings are content specific - sky is transformed in one way, trees in a different. way, etc. Therefore, Van Gogh-like images generated via style transfer method, do not capture the real logic of his art, and the same holds for other examples generated with this method.)

On the one hand, neural networks approach indeed departs from the methods of computer art and design developed earlier. With this technology, we don't program a computer explicitly to generate new objects using a sequence of steps, a system or rules, or in some other way that we have to specify in all details. Instead, a network itself extracts deep structure from a set of cultural artifacts and then generates new artfacts. Does this mean that we finally have real "artistic AI," the true "art intelligence"? Maybe not yet. There are at least three points in this process where a human author makes explicit choices and controls what computer would do. First, a human designs network architecture and also an algorithm used to train a network (or selects from the existing ones). Second, the human creates the training set. Third, the human selects what in her/his views are most successful artifacts from many more the network generates.

Given all this human curation and control, we can't claim that generation of cultural artifacts via machine learning / neural networks is more "intelligent", i.e. shows the higher level of autonomy than any other computer art method. Each of these methods also includes human decisions and choices and execution of algorithms. Thus, machine learning is not a more advanced form of artistic AI than geometric drawings of the first computer artists, cellular automata artworks, or many interactive computer-driven installations. In fact, I think that machine learning approach is more restrictive than the earlier approaches, since a human makes decisions in so many points in the process. (And if we recall our earlier discussions of expanding boundaries of art, interactive installations are more interesting than a computer that generates van Gogh-like images.)

How do we translate these arguments into another possible definition of "AI arts"? We can now say that all methods developed in computer art since the 1950's are equally valid parts of "AIarts" - from a program in processing generating geometric simple patterns, or d3 code generating interactive data visualization to a deep neural network trained on very big data. *What defines whether something is "AI" is not a method but the amount and type of control we exercise over algorithmic process.*

III.

For our third attempt at "AI arts" definition, let us focus now on the core idea of machine learning / neural networks approach - the computer automatically extracting common patterns from a group of artifacts. This aspect of machine learning is indeed a new thing in a longer computer art history. A computer that by itself can learn the structure of the world is an impressive proposition, even if such a computer is still (or maybe always) quite different from a human child doing this - because the world of training set objects. carefully curated by a human engineer is an artificial world, far removed from the heterogeneity, diversity and noises of the real world that a child is exposed to (and also because we have to construct the network layers for extracting patterns ourselves, as opposed to the network evolving and constructing itself.)

So, shall we get excited if a computer that learned patterns from a training set can generate new artifacts with the same patterns? It is a satisfying proposition at first because here we see a computer that appears to replicate human cultural behavior and capturing its essence. What is it? Over many thousands of years of human culture making, the diverse cultural expressions that developed in different geographic areas, in different materials, by anonymous groups or later by named authors all have one thing in common: cultural expressions created in one area, in one period or by one group share some common patterns. Their ornaments, clothing, decorations, designs, music, performances, rituals and so do not vary arbitrary - they have a "style," i.e. a system of rules, constraints and affordances. They define what is possible within a given style, what is less likely, and what is impossible. The coherence of a style in traditional cultures is very strong, and this is why styles of artifacts are used by archeologists to date periods of human civilizations and understand their development.

A particular style system is visible not only across the artifacts remaining from a particular civilization (which, on a closer look, is always on a closer look is a meeting point of cultural vectors from different places), but also within a single artifact. Consider a pattern covering the clothing or a vessel from some historical civilization. If they are covered with some ornament, the style of this ornament does not change dramatically across the surface it covers. In fact, if we select a smaller area of this ornament, we can write a computer program that can predict pretty well the rest of the ornament.

The phenomenon of a systematic style was present in all historical civilizations and periods that I am aware of. Surprisingly, it did not disappear in the modern art and design, despite modernists' revolt against traditional aesthetics (e.g., refusal of symmetry, adoption of dynamic composition, text without capital letters, valuing shock over harmony, etc.) Whether it is a painting by Sonia Delaney, Lyubov Popova, or Jackson Pollock, the style system does not change across one painting. In the same way as in traditional ornaments and decorations in ancient and folk arts, here the patterns operating in one large part of an image are the same we find in other parts. (To be fair, I should note that there are also differences in this between particular modern artists. Jackson Pollock's mature, abstract expressionist paintings are indeed almost like traditional ornaments, with one part containing all DNA of the whole painting. But with many other artists such as Delaney or Malevich, while some patterns remain the same across the full painting, on another scale of the overall compositions, some elements may not be predicted from examining only small parts.)

Why did humans throughout their history keep creating things with this single meta-pattern, i.e. a systematic rigid style within one group of artifacts, and also within a single artifact? Why are we not interested in creating images that have one aesthetic system in one image corner and completely different systems in another corner? As I already mentioned, this deep structure of human culture was not challenged by modernist inventions, including collage and montage tactics developed in the 1920's. Later remix practices (1980-) made possible by electronics, and yet, later digital computers also did not challenge it. Yes, a remix can move between samples drawn from very different aesthetic systems – but once you listen to a part of a remix song, the system established there typically does not change in the rest of the remix song. (The same is true of music videos.)

Given this, when we teach computers to extract patterns from large sets of artifacts in a single aesthetic system, and then generate new artifacts that belong to the same system, is this really radical? We force computers to create like us - like we did for tens of thousands of years. In my opinion, it would be more radical to use computers to break away from this meta pattern of human culture. Let's teach computers to do something we humans can't do - to move between different systems and aesthetics within a single work, or from work to a work in a series. Modernist revolution that had its high moment a hundred years ago already started questioning some of the basic assumptions of human aesthetics, so maybe computers can help us to continue this process.

One relevant example of AI research is MuseNet, "a deep neural network that can generate 4-minute musical compositions with 10 different instruments and can combine styles from country to Mozart to The Beatles."[4] (The system can generate new music in the style of a particular composer and also combine these styles. In one instance, "the model is given the first 6 notes of a Chopin Nocturne, but is asked to generate a piece in a pop style with piano, drums, bass, and guitar.")

Exploring such directions is only one of many possible ways to push computers to do something that both appeals to us aesthetically and semantically, and at the same time, had yet to be done in human civilization. It's a common thing to say that if computers can be programed to create really novel art, we will not recognise it as art, or will not understand it. But maybe this is not that interesting or ground-breaking. Instead, we may want to focus on what lies between such "art for computers", non-comprehensible to humans, and the universe of all aesthetic possibilities already realised in human civilizations (including our own modernist and contemporary periods). Certainly, so many possibilities can be explored in this vast "in between."

This is, then, my third definition of "AI arts." *"AI art" is a type of art that we humans are not able to create because of the limitations of our bodies, brains, and other constraints.* One such possibility I sketched above is computer generated objects, media, situations and experiences that do not have the usual systematicness and predictability of human arts – but they are not random either, they don't mechanically juxtapose elements just to shock, and they are not simply examples of remix aesthetics. Instead, they systematically have something other that we have not seen yet even in the most radical modern music, sculpture, architecture, photography, etc. Something that we would deeply love once we see it. Something that, as all great art before, will expand who we are as humans.

Notes

1. Sanakoyeu Artsiom, Dmytro Kotovenko, Sabine Lang, Bj.rn Ommer, "A Style-AwareContent Loss for Real-time HD Style Transfer", https://arxiv.org/abs/1807.10201.
2. A machine has passed the Turing test once it exhibits a form of intelligencethat is sufficient for a trained human interlocutor to be unawarewhether he/she is communicating with a machine or with another human being.
3. For examples of this work, see https://arxiv.org/pdf/1807.10201.pdf.
4. Payne, Christine. "MuseNet." *OpenAI,* 25 Apr. 2019, https://openai.com/research/musenet.

twist

Dance-twist twisted, discoveries and distortions, the transmutation of age-old drama, the love love love, GAIA data boom, old space traveller Copernicus streams data, cross-border cross-human AI, tautologic tantrums of the real, n dimensions multiverse, quarks and pebbles on a shore, oracles instead of horoscopes, silicon talking unfathomable sense, no sense a tiny Turing stumble, twist into hyperspace, stars awaiting entanglement, how will you twist into this bouquet of futures?

Then the twist, maybe into nothingness like dark matter, oscillographs murmuring of quanta, a primordial twist like soup or a quantum twist, new horizons arising where least expected, Big Sun Big Data new patterns, the old transmuting into unrecognisable, yet life is love is loot is the question of intelligence still unanswered violence: Eve hanging on a cross, love as the trick of finding what you didn't lose, limitless, or will we resort to violence, again, again blotting out the hominescent beckoning future, the pains of becoming staining the day staining history, twist reboot the mind five minutes of nothing, then again newly veering off off, old violence persisting, old ghosts resurging in new intelligence this work is always illimitably new in each life, yours, the shape-shifting dance a conspiracy between silicon and evolution, we twist into the future asking oracles but why would the future be different or distorted less than human more than human is human a twist in progress?

Quantum Oscillographs

DataWe

Silicon Sinapse

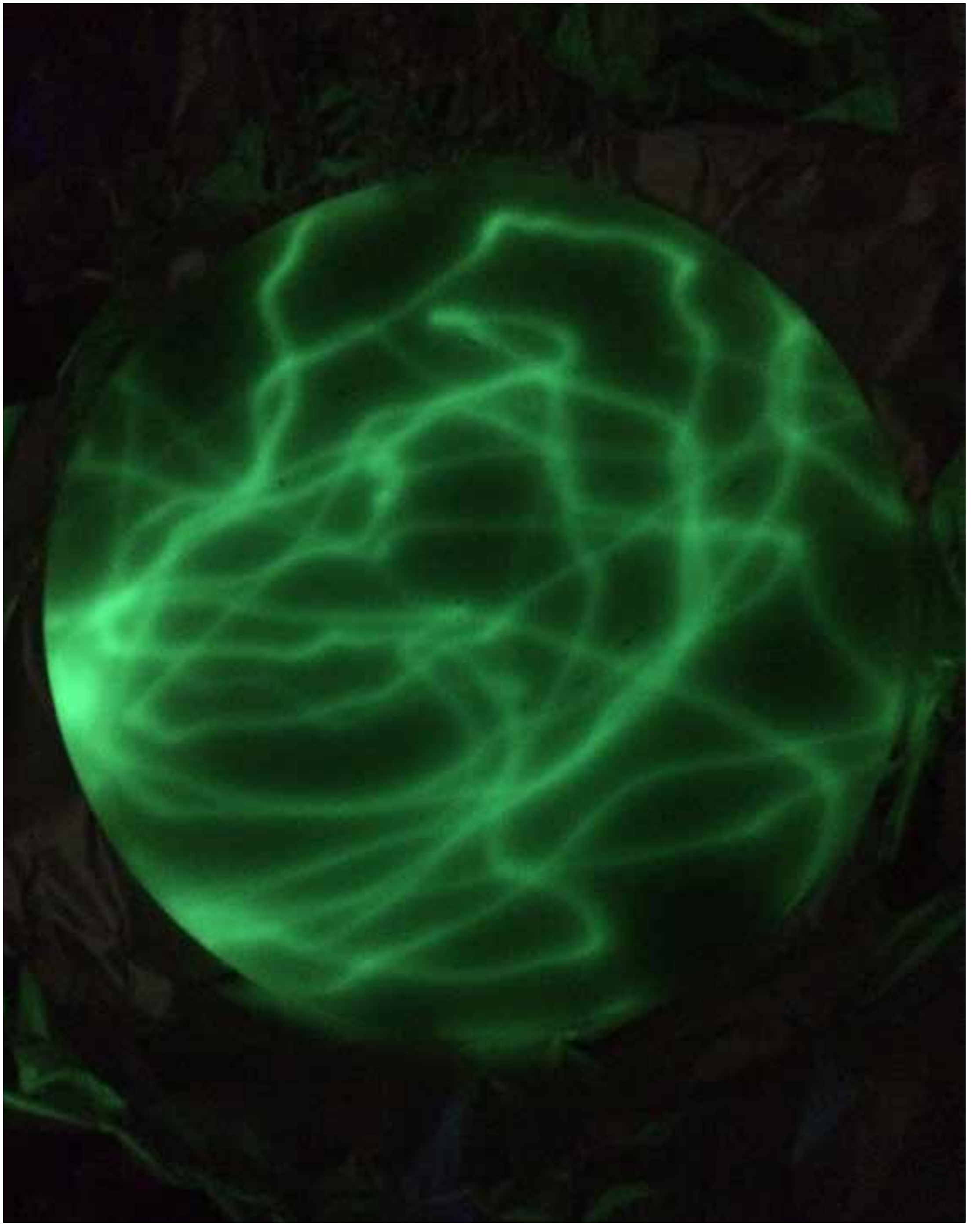
Portrait of the AI
as a Young Cyber Oracle

Quantum Oscillographs

Artist
Melanie King

Scientists
Flavio Bono
Constantin Coutsomitros
Eugenio Gutierrez

Quantum Oscillographs,
SciArt Datami project, 2019
Installation
Mixed media: Phosphorescent Resin disc, mirror ball motor,
wLaser-speaker module



Quantum Oscillographs,
Resonances III Datami
Melanie King,
materials, 2019

Quantum Oscillographs

Melanie King

Description of Work

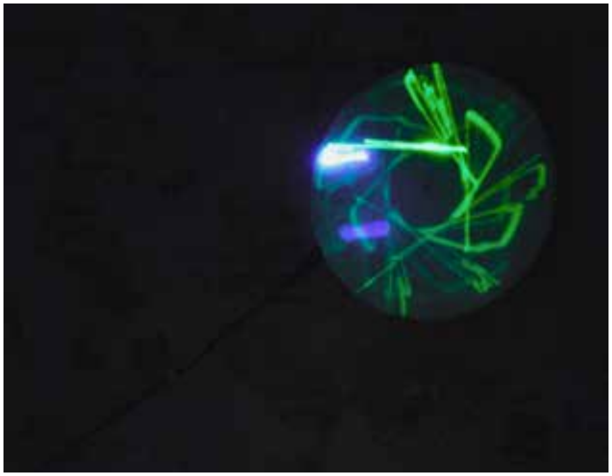
For Resonances III, I present an installation of two *Quantum Oscillographs*. At the JRC, quantum physicist Constantin Coutsomitros passed electronic pulses through his quantum walks experiment. This experiment involved a laser beam pointed at a crystal. The crystal split the beam into two entangled beams, and the original beam was absorbed by a special filter so that it does not interfere with the other two entangled beams. These two beams were connected and could "feel" the same interference. When one beam was altered, the other beam followed suit.

My *Quantum Oscillographs* visually represents the two entangled beams. Visually, the oscillographs should look exactly the same, however it is up to the observer to detect any differences. This oscillograph uses photoacoustic technology, where sonified data moves a laser which is drawn upon a phosphorescent disc. This disc then re-emits the laser light slowly while rotating, allowing the lasers' intricate drawings to be seen.

Excursus on vision of Big Data and Datami

The Datami Festival aims to get artists and scientists together in order to reflect upon the importance of Big Data in our everyday lives. As an artist, I found the visits to the Joint Research Centre incredibly eye-opening. My overriding feeling after visiting the JRC was hope, as I was able to see how scientists are creating exciting solutions that could have a huge impact on the sustainability of our future, with innovations such as electrical car chargers and solar panels, which were pioneered at the JRC some time ago.

During my residency at the JRC, I worked with Constantin "Costas" Coutsomitros, allowing me to discover how his quantum walks experiment operated. The



experiment unfolds as follows: a laser beam is pointed at a crystal. The crystal splits the beam into two entangled beams, and the original beam is absorbed by a special filter so that it does not interfere with the other two entangled beams. These two beams are connected and can feel the same interference. When one beam is altered, the other beam follows suit.

Visiting Costas's laboratory was an incredibly interesting experience, as he was experimenting with technologies that emit very minute electrical activities. For example, Costas used a machine that detected my brain waves whilst I was observing his laboratory. He has also invented a plastic-detecting machine, which could one day become very useful in our plastic-contaminated world. Following my visit to the JRC, I used the data that Costas provided me from the Quantum Walks photon detectors, to create an audio file. I used these files to create a *Quantum Entanglement Oscillograph*.

The first oscillograph measures the data connected to the first photon. The second oscillograph represents the other photon, which should also feel the interference of the first data stream. Visually, the oscillographs should look exactly the same, but it is up to the observer to detect any eventual differences. The entangled photons that Costas is working with have far-reaching implications. Theoretically, entangled photons can feel the same interference across the entire universe simultaneously, without the limita-

Quantum Oscillographs,
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 – 19 January 2020
Installation views
Photos Melanie King,
Cristina Fiordimela

Picture on the previous page:
Quantum Oscillographs,
Resin disc
Photo Melanie King

tions of the speed of light. Thus, the concept of entangled photons has revolutionised our understanding of how the universe works.

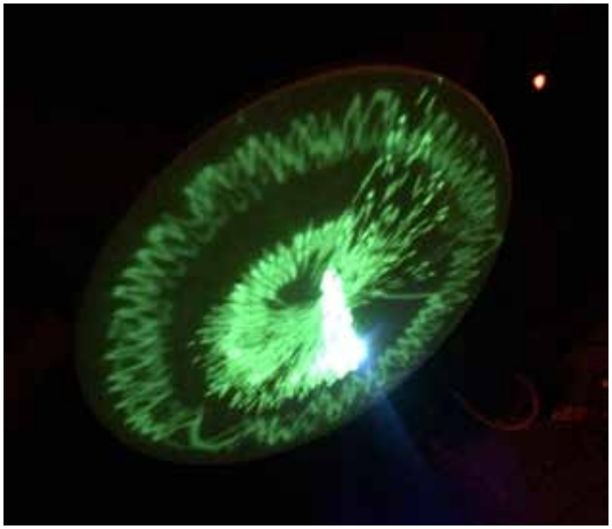
Within my practice-based PhD research at the Royal College of Art, I am looking at the area of new materialism. New Materialism is an area of philosophy that redefines our understanding of matter, based on contemporary science and quantum physics.

Karen Barad, a philosopher who was originally trained in the field of particle physics, has become one of the prominent theorists of New Materialism. In her book, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*[1] , Barad suggests that the language often used within todays's philosophy relies on older understandings of physics that are limited to the atom. In *Vibrant Matter: A Political Ecology of Things*[2] , Jane Bennett compares *Primordia*, found in Lucretius' *De Rerum Natura*, to what we know today as atoms and quarks. *Primordia, Atoms, Particles* –these are the building blocks which combine to create physical matter.

The etymology of the word atom derives from the Greek word *atomos*, meaning indivisible, which is used to describe the smallest component of ordinary matter. Atoms and particles are stacked together in different formations, which can be used to build anything such as a human, a tree, plastic, photosensitive emulsion or even a star. Looking at the universe on a quantum level, we can deduce that every observable thing is made from the same stuff. This is discussed in Carl Sagan's *Cosmic Connection: An Extraterrestrial Perspective.*

> *Our Sun is a second or third-generation star. All of the rocky and metallic material we stand on, the iron in our blood, the calcium in our teeth, the carbon in our genes, were produced billions of years ago in the interior of a red giant star. We are made of star-stuff.*[3]

In her book, Barad reveals how quantum physics allows us to understand that we are intrinsically connected to what we observe and work with. The Quantum Walks Experiment designed by Costas demonstrates

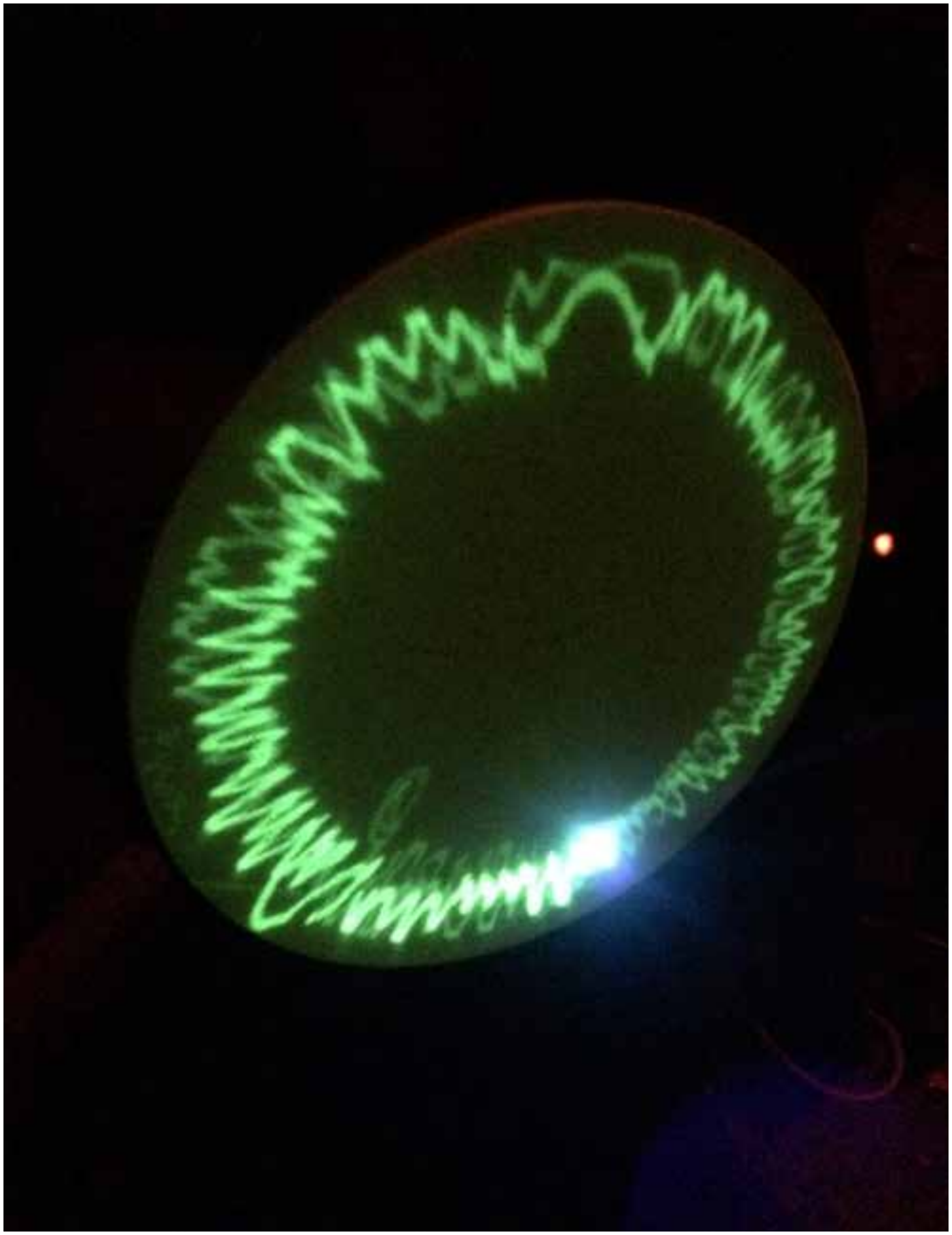


that photons are entangled and feel the same interference: they are apart yet connected simultaneously. Within Barad's interpretation, the photons are not just joined, but lack an independent and self-contained existence[4]. It is this lack of independent, self-contained existence that allows Barad to consider how beings are interconnected beyond the atom, suggesting that we constrict ourselves within imagined borders and constructed boundaries.

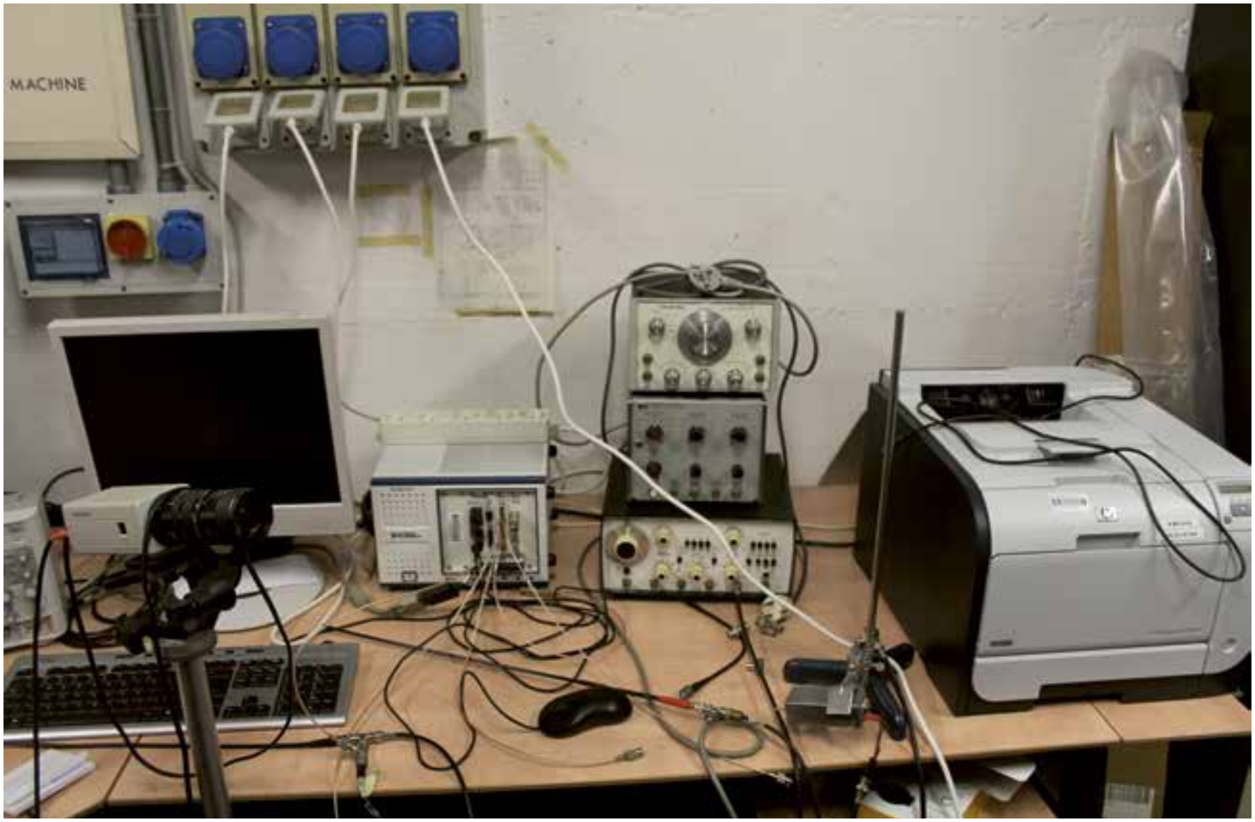
For example, Barad highlights how we construct boundaries between the human and non-human, believing that we are not part of the natural world we live in. This disconnect from nature has become a problem, as animals become extinct and Earth becomes warmer. During this time of increasing separation and ecological catastrophe, I believe that it is vitally important to consider the forces that connect us.

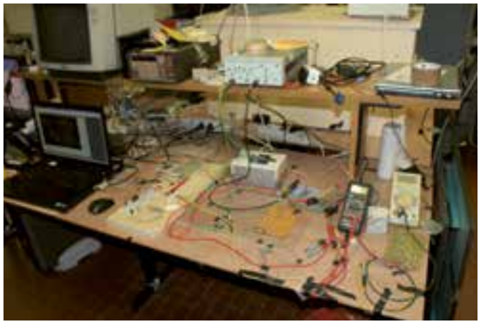
Notes

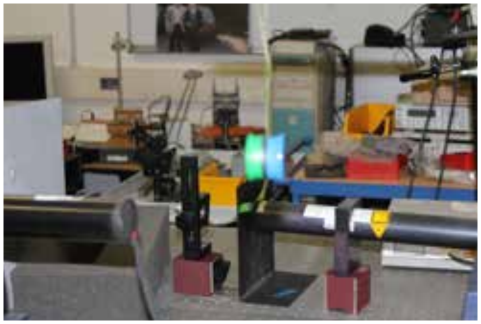
1. Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*, Durham, NC, Duke University Press, 2007.
2. Jane Bennett, *Vibrant Matter: A Political Ecology of Things*, Durham, NC, Duke University Press, 2010.
3. Carl Sagan, *The Cosmic Connection*, New York, Anchor Press, 1973, 190.
4. Karen Barad, oc, preface.

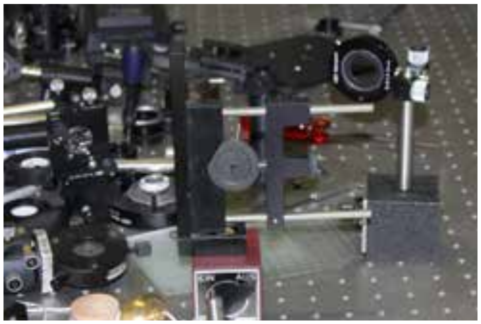


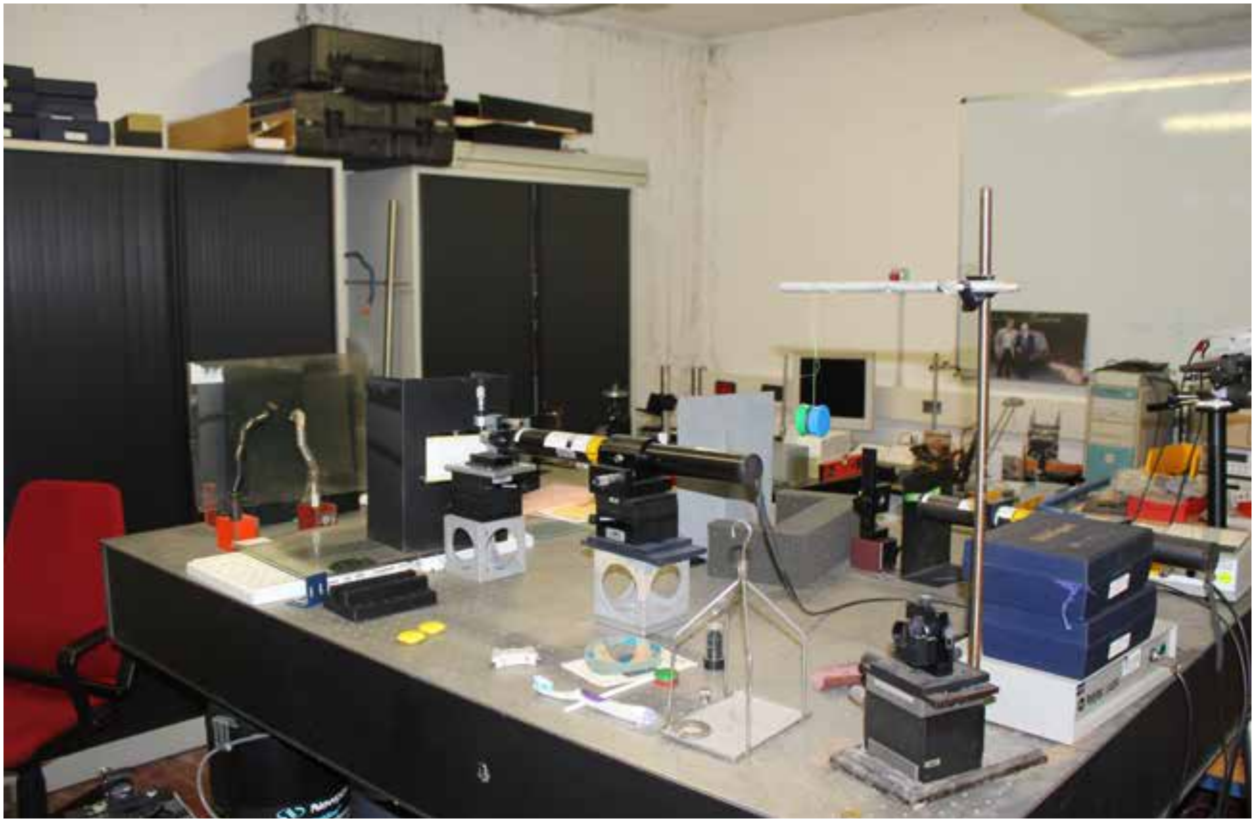
Pictures on this page
and on the previous page:
Quantum Oscillographs,
Cosmic Ray Oscillograph
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view:
Photo Melanie King


MACHINE

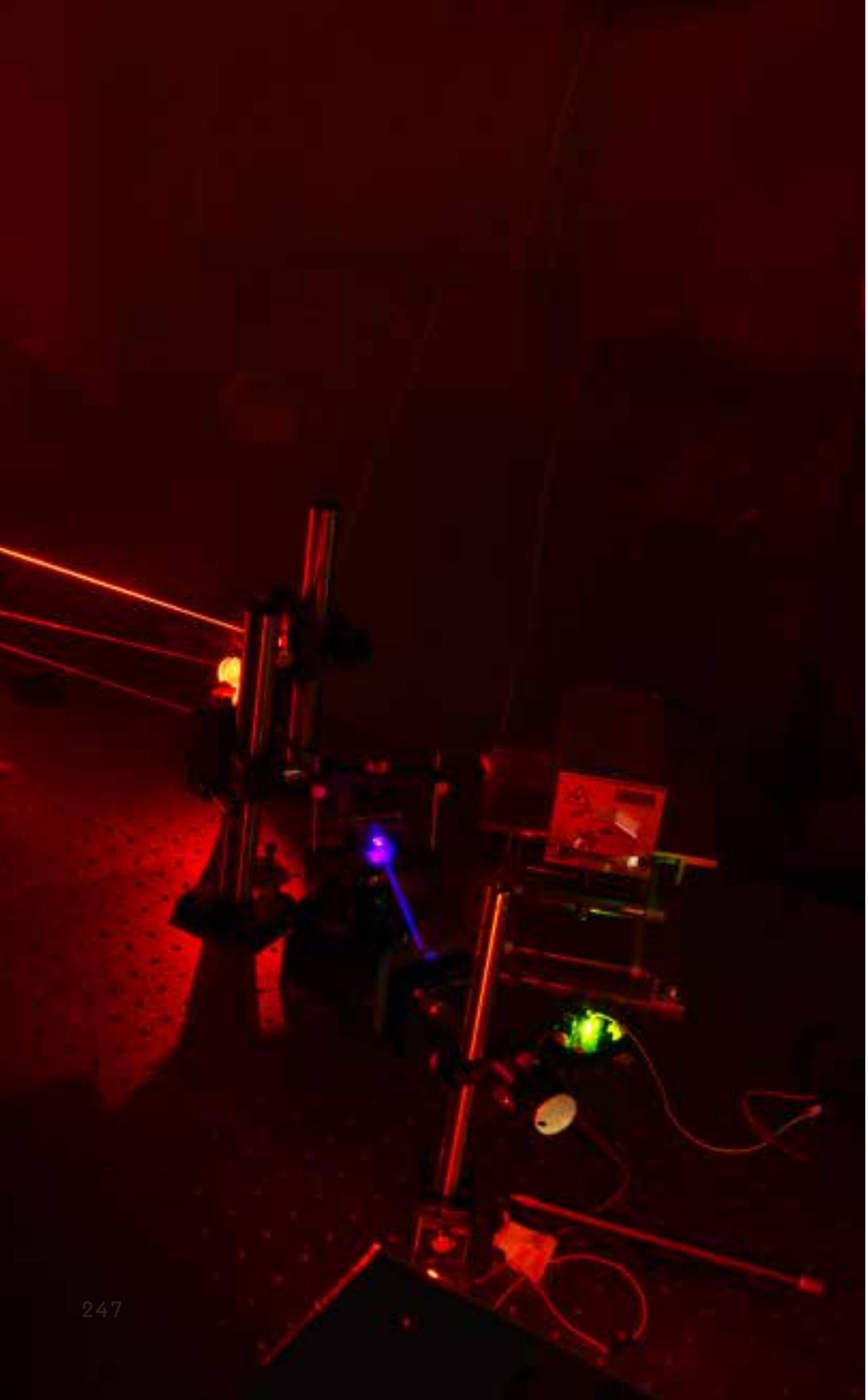








Costas' Lab,
Laboratory in Building 48, JRC Ispra site, 2019
Photos Constantin Coutsomitros



Quantum Sensors and Entangled Walks
Experimental Set-up,
QATWALKS Laboratory,
JRC Isprs site
Photo Flavio Bono
and Constantin Coutsomitros

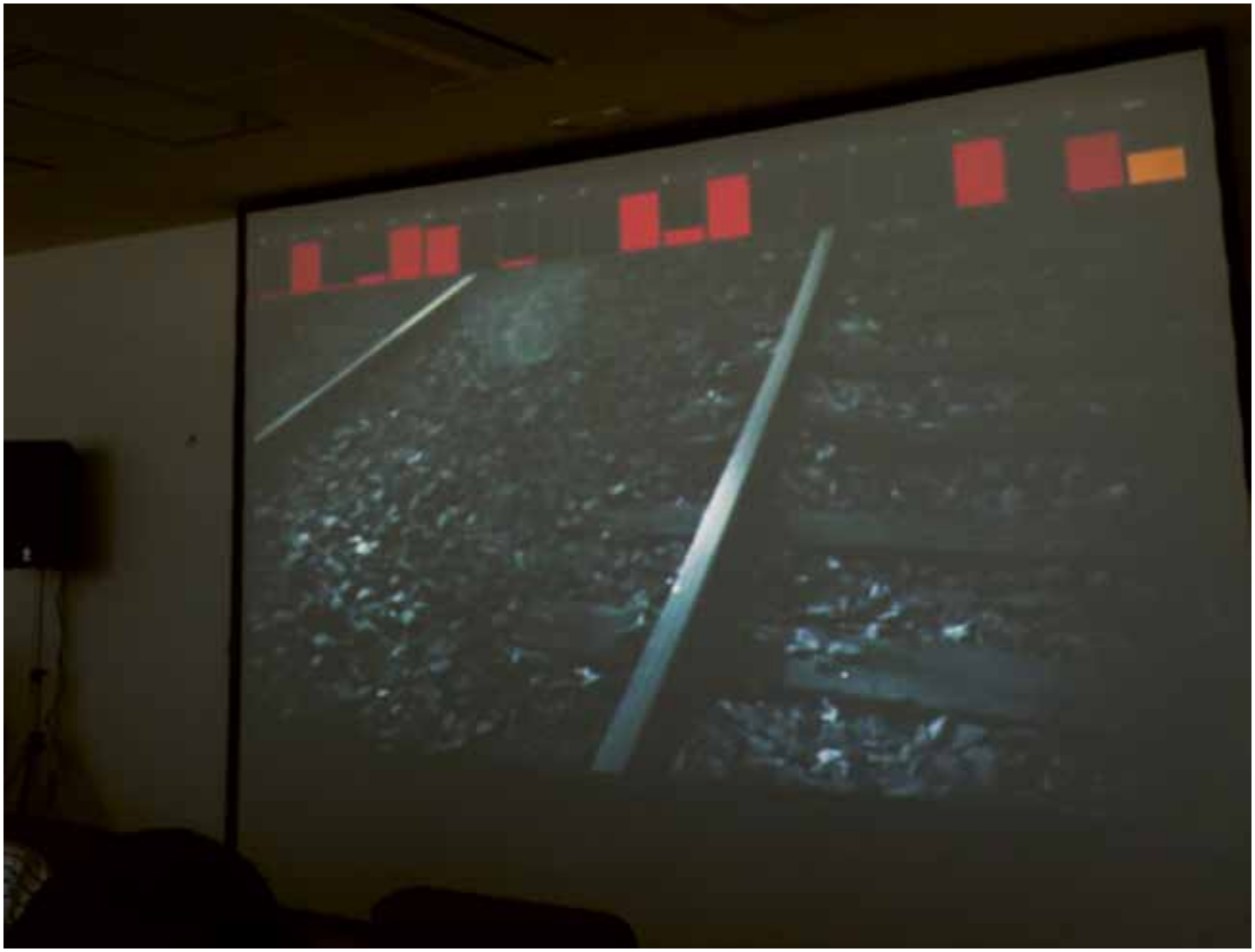
DataWe

Artists
Aleksander Väljamäe/Amal Mokded

Scientists
Massimo Craglia
Blagoj Delipetrev
David Mair
Laura Smillie

Collaborators
Maria Hansar, neurotheatre producer
Taavet Jansen, neuro-dramaturgy
Valentin Siltsenko, narrative engine programmer
and visual design
Daniel Irabien Peniche and Mary Marinopoulou,
project assistants,cinematographers, editors
Ben Ighoyota, system network solution
Matti Mõttus, eye-tracking recordings
Ana Fred and Patrícia Bota, Machine Learning, Instituto
de Telecomunicações and Technical University of Lisbon
Hugo Plácido da Silva, Physiological computing, Instituto
de Telecomunicações

DataWe,
SciArt Datami project, 2019
Neurocinema, 2:35



DataWe,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Neurocinema showing 14 October 2019
Photo Amal Mokded

Aleksander Väljamäe statement

I am grateful to be included in the Resonances III Festival as an artist. Since the start of my scientific career in 2004, I have been trying to combine art and science. I am particularly interested in how modern multisensory media can be used to manipulate human perceptual, cognitive and emotional processes. Working mainly on future emerging technology projects, over the years I developed the concept of neurocinema and neurotheatre.

Both concepts include interactive media and real-time physiological data monitoring, which underlies user reactions and a closed-loop between the audience and the media content. The most fascinating part of these new art forms is that they can tap into the unconscious processes of the spectators. Dual process theory set by William James and followed by others such as John Cacioppo and Daniel Kahneman, inspires this emerging research field of neurodramaturgy.

Meeting JRC scientists from various units has been an overwhelming experience for me – there were so many possibilities, research groups and directions that were directly linked to my interests. It was also fascinating to see how science informs policy decisions. Finally, we converged to work with three groups of people, EU Science HUB and the project "Enlightenment 2.0", AI Watch and Digitranscope.

Amal Mokded statement

I focused my research on the problem of invisible violence: reflecting on how to create a trace and proof of this suffered violence which had been kept secret. I had to think about how I would build my works – video, art and painting – and how their aesthetics and impact would make sense. I chose to highlight the impact of physical and psychological violence on the victim, creating images and stories to show the growing effects of violence on the body and on the image of oneself.

Video art is deeply linked to the feminist struggle. It allows to record, memorise and give a voice to the repressed. Video has technical qualities likely to participate in the treatment of certain mental disorders like neurosis. The neurocinema show *DataWe* allows me to approach spectators differently, making me see in a different way what they feel and how they judge me. It will have an impact on my art process and will help me to understand how human emotions work. I think one of our most primal needs as humans is to understand ourselves as well as the world around us, and then to share that understanding.

There is no place like home is the plunge of a temporality in another.

There is no place like home is the experience of an exhibition, it is the starting point of physical or introspective displacement.

The spaces, places are visible paths on the images and it makes them beyond knowledge.

The exact time of capture belongs to a temporality that we can never recover.

Thus the chaos appears, it comes out of nowhere, in the face of the city and nature.

It is chaotic and structural at the same time.

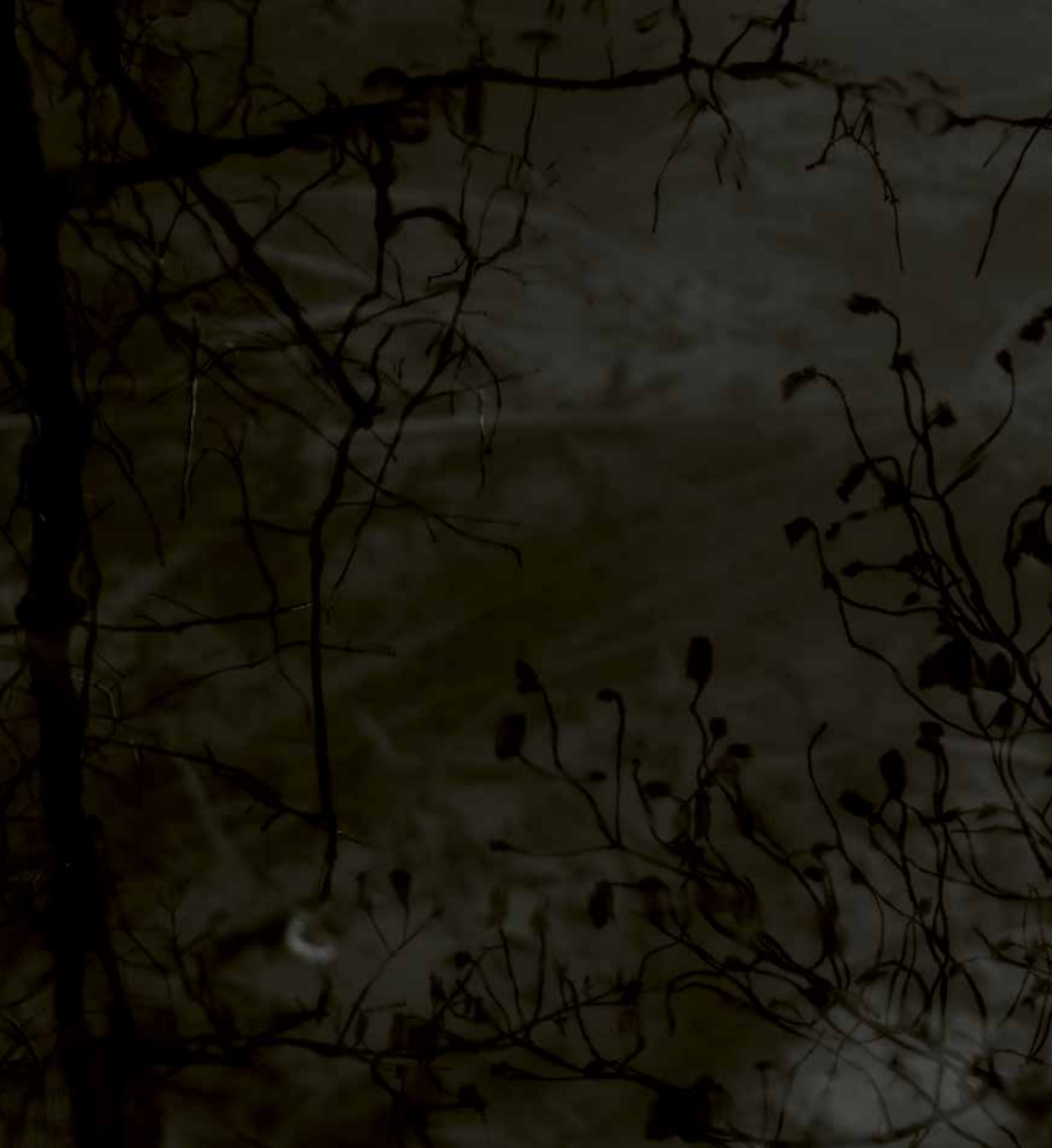
DataWe project and its connection to JRC activities

Aleksander Väljamäe, Amal Mokded

The discussions with JRC scientists facilitated the creation of the new concept of *NeuroSecurity Center* by the *DataWe* project team. While in a traditional sense, neurosecurity refers to a set of neuroethical principles for a neural device of the user, we extend this to media manipulations that directly undermine critical reception of information content. *NeuroSecurity Center* embraces a number of topics including neuroimaging, studying behavioural and emotional reactions of users to media, analysis of physiological data streams, user modelling, and finally, providing feedback to the users about the aggressive and manipulative media.

The *DataWe* performance is a mixture between themes and technologies of *NeuroSecurity Center* and the audio-visual world of an Arabic artist-immigrant from Tunisia, Amal Mokded. The physiological data captured and

Pictures on this page and on the next pages: Resonances III Datami*, DataWe,* The selected set of Amal Mokded's images are part of the Chaos Echos installation at CEAAC*,* The European Centre for Contemporary Artistic Actions in Strasbourg*,* France



analysed during the performance is a new digital essence of human existence, it is *DataWe*. All JRC scientists also agreed that the concept of neurocinema performance as a data collection tool provides a new methodological solution. In the *DataWe* show, we dive into a dystopian future where there is no individuality, and where people form groups, meta-brain structures, that work collectively on various tasks. During the show, the group of neuronauts has a new task: to collectively evaluate the digital replica of an Arabic immigrant artist. An AI-powered neurocinematic system has access to all audio-visual materials of the artist, "Amal's world", and re-edits it according to the neuronauts' affective reactions. Audio-visual sequences that contain violence, intimacy, manipulation, mutism and political protest now probe the group's meta-brain.

In the project, we aim to raise awareness by asking ourselves questions like: can excessive exposure to visual violence lead to a degrading representation of a human? Can images not only provoke violence but also stop it? How fast do we adapt to new social norms, tolerating more violence and aggression (emotional conformism)? Can emotionally charged media be used as a strategy to attract and manipulate our fast decision making system while factual information is conveyed?

JRC scientists: David Mair, Laura Smillie

The EU Science HUB project "Enlightenment 2.0" explores the extent to which facts, values and social relations affect political behaviour and decision-making. The recent report, *Understanding our political nature: how to put knowledge and reason at the heart of policy-making*, inspired DataWe through topics of collective and emotional intelligence, values and identities, and finally, framings, metaphors and narratives. The team also suggested concentrating on the migration issue as the main theme of the performance.

I find the concept of NeuroSecurity Center intriguing -
what would happen if it were hacked?


HACKER

JRC scientist: Blagoj Delipetrev

AI Watch is an emerging JRC knowledge service to monitor the development, uptake and impact of Artificial Intelligence for Europe. When discussing the *NeuroSecurity Center* concept, Dr. Delipetrev pointed out some recent interviews by Yuval Noah Harari, where he highlights the danger of the combined power of AI-based analytics and advanced neurotechnologies. If each individual's conscious and, potentially unconscious, behavioural and emotional patterns will be available to big corporations, surveillance capitalism may inevitably lead to future societies of control. By showing these media attacks and modulations, by showing how they are reacting to the content, we allow people a chance to get a better understanding of how their emotions are affected by the actions of these agents.

DataWe addresses an important aspect of AI that is linked to the analysis of brain and neuronal data. It definitely offers a beginning of an interesting future research project.

JRC scientist: Massimo Craglia

Digitranscope is a research project of the JRC Centre for Advanced Studies that focuses on the governance of digitally transformed human societies. When discussing with the Digitranscope team, the first thing that appeared and stayed at the core of the performance was the metaphor of the jurors, who we called "neuronauts" at the later stages of the project. Other topics that resonate with Digitranscope are co-creation of data, new social forms and new strategies for governance.

I am glad I convinced Aleksander to read the last parts of Asimov's Foundation series, where the concept of mind control and collective mind were insightfully developed.

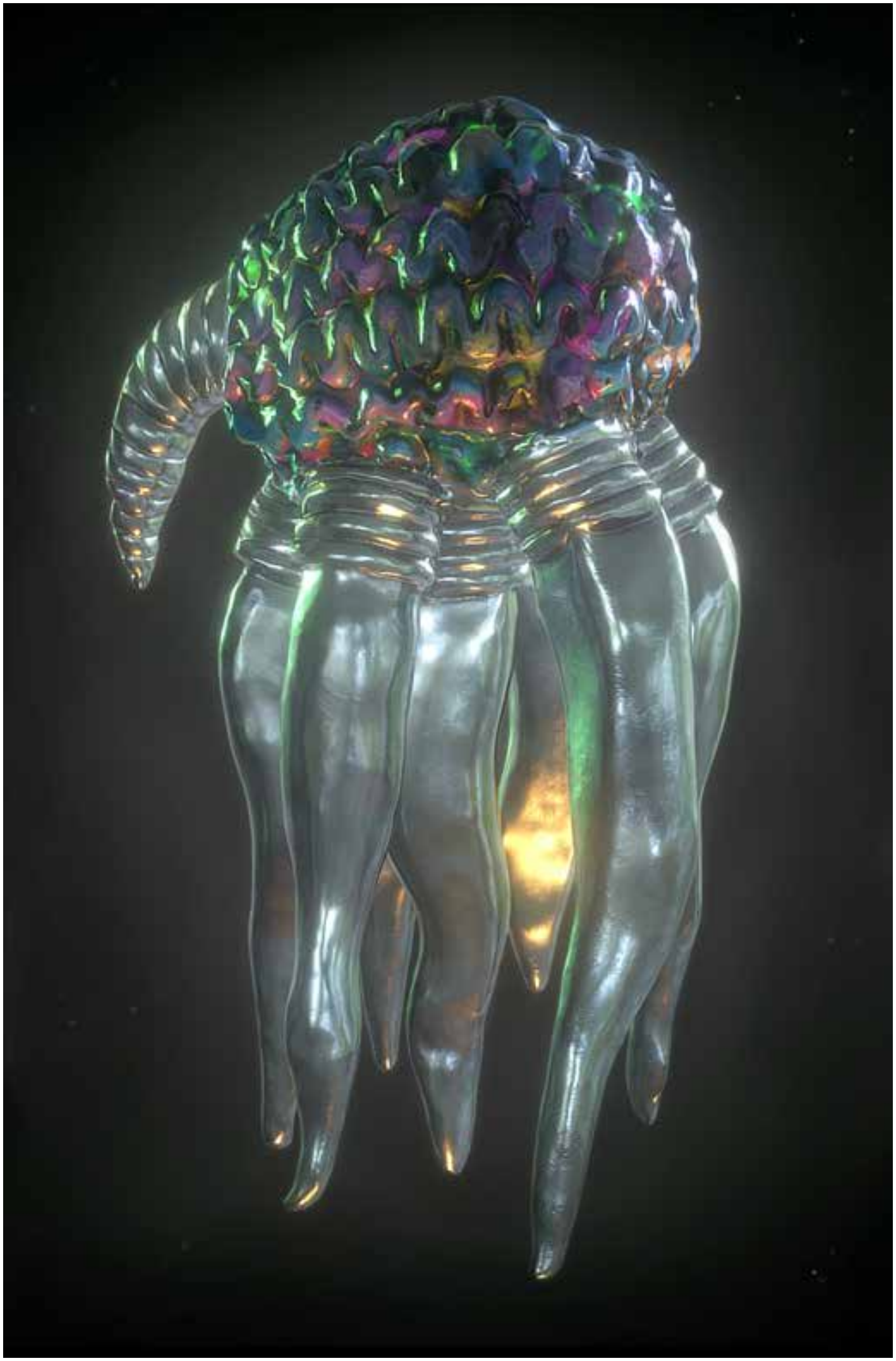
Silicon Synapse

Artist
AlanJames Burns

Scientists
Thierry Benoist
Vicky Charisi
Nicole Dewandre
Emilia Gomez Gutierrez

Collaborators
Caroline Cowley, public art co-ordinator
Sue Rainsford, writer
Jason Dunne, concept artist
Michael O'Riordan, composer
Robert McGregor, Joe Daly, Karen Peaking,
Kevin Ryan and Oisin Carroll, unity graphics
Emer Lynch, project support

Silicon Synapse,
SciArt Datami project, 2019w
Virtual Reality, 18 channel psychoacoustic
audio installation/mixed for headphones, 17'



Silicon Synapse,
Resonances III
Datami
AlanJames Burns,
Portrait, 2019

Silicon Synapse

AlanJames Burns

Virtual Reality and psycho-acoustic installation

17 minutes

Silicon Synapse is an immersive virtual reality and psycho-acoustic experience that simulates a journey into the personified, conscious mind of Technology. This sensory artwork is experienced alone, one person at a time, hearing the inner dialogue of Technology's mind as it ruminates over both sides of a lovers' quarrel. Technology and its life partner, Nature, argue about the sustainability of their relationship and their future as a couple. This trans-human, dream-like conscious realm engulfs the viewer as they travel through intense audio and visual experiences.

Information technology causes untold effects on human cognitive function and our conscious experience: from creating heightened attention spans and advancing neurological/motor skills, to altering the very ways that we process information. *Silicon Synapse* is a self-reflexive exploration of wearable Virtual Reality technology and immersive media. The art piece focuses on the cognitive impact of high-tech through the lenses of the very mediums that are altering and shaping the future of our inner experiences. The climate crisis is immeasurably intertwined with technological growth. *Silicon Synapse* tries to comprehend sustainability by paralleling Technology and Nature to the relationship of two humans madly in love but incompatible with each other. It is a lustful and exciting, yet destructive, relationship.

The following dialogue, written by Sue Rainsford and delivered by Peter Corboy, was experienced by participants as they moved through the virtual environment.

Virtual Reality's Poetry

fo-veal
iso-morph
equiv
lent
lament
somat
ic
nave
novice
import
imp-isset-ass-et
lang
libs
spar-var -ava
avunc
ular
node
snip
snipe
snippet
slip
slide
sliver
slink
slope
slow
slender
slunk
sun
sunk
clo, clung to oak—
cloak, cloaking to coagulate
and crawlers
crush
about collecting, gathering and heaping
a chain that links and links
soon: to lament this
luminate
what you thought luxuriate
but is only languish

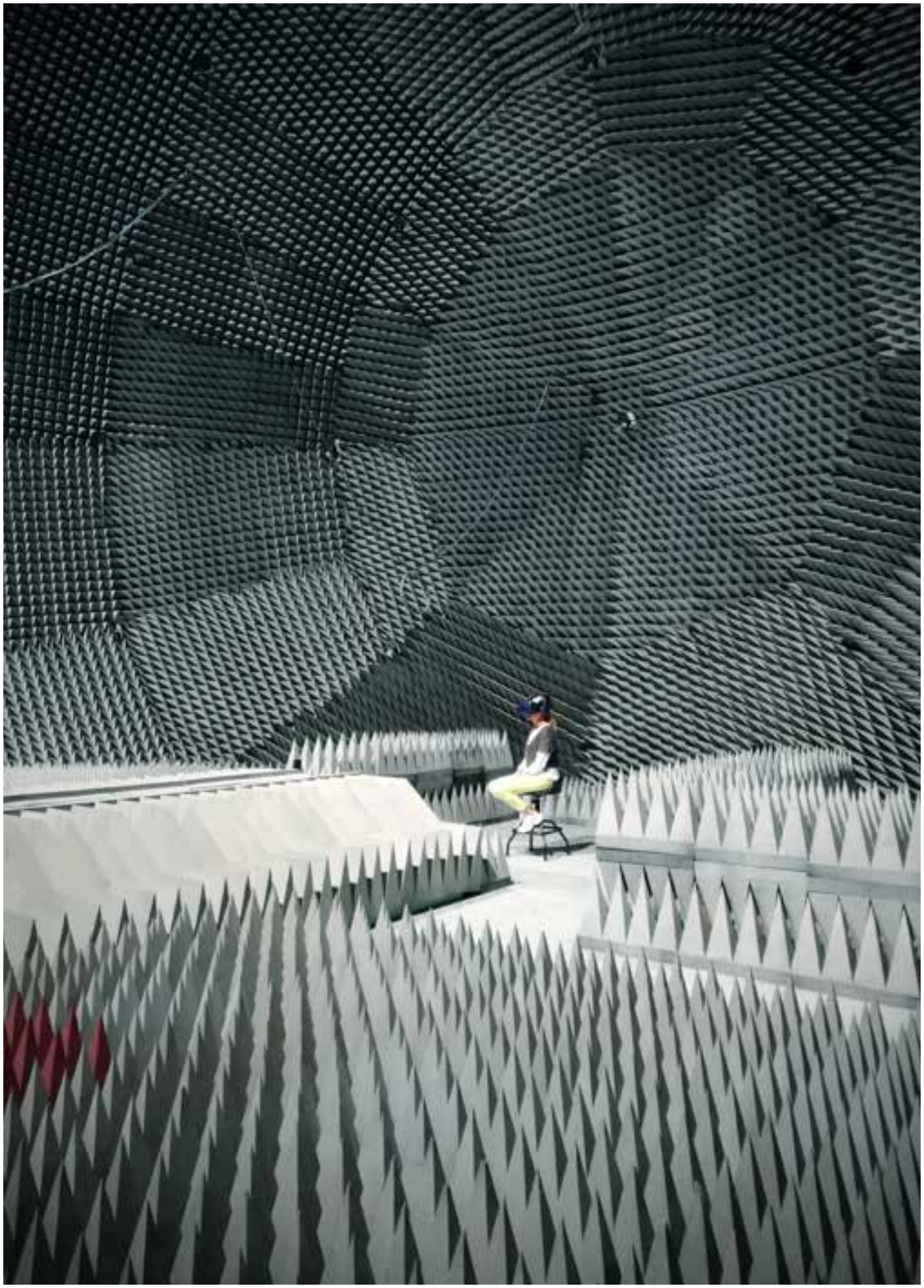
Silicon Synapse,
prototype 18 channel
audio installation
Dubiln, Ireland, 2019
Photo Trevor Whelan

lipid
limpid
limp
lull
lullaby
lung
a topic topical as it tags, gives title
teasing tug
‘til density, self-replenishing
plen plenty plenitude
produces juice
flew, flipper, fluid
floral
fungal
most robust flower
prod
jus
jinx
of proximate and proof provided
rotund
ripple
rotate
another anchor
lashes and lapel
cold—collapse and cool
a curl
uncoiling
inoculate and impair
twig to tree
twinning
unique and unified
uncertain and undeveloped
certainly that which is smooth and
immaterial
seeking optimal means must
optimize
an ocular, fibrous filigree flare
at this base level, might we bionize
an eye, its sight
ruptured by
a pin
pricking
granite

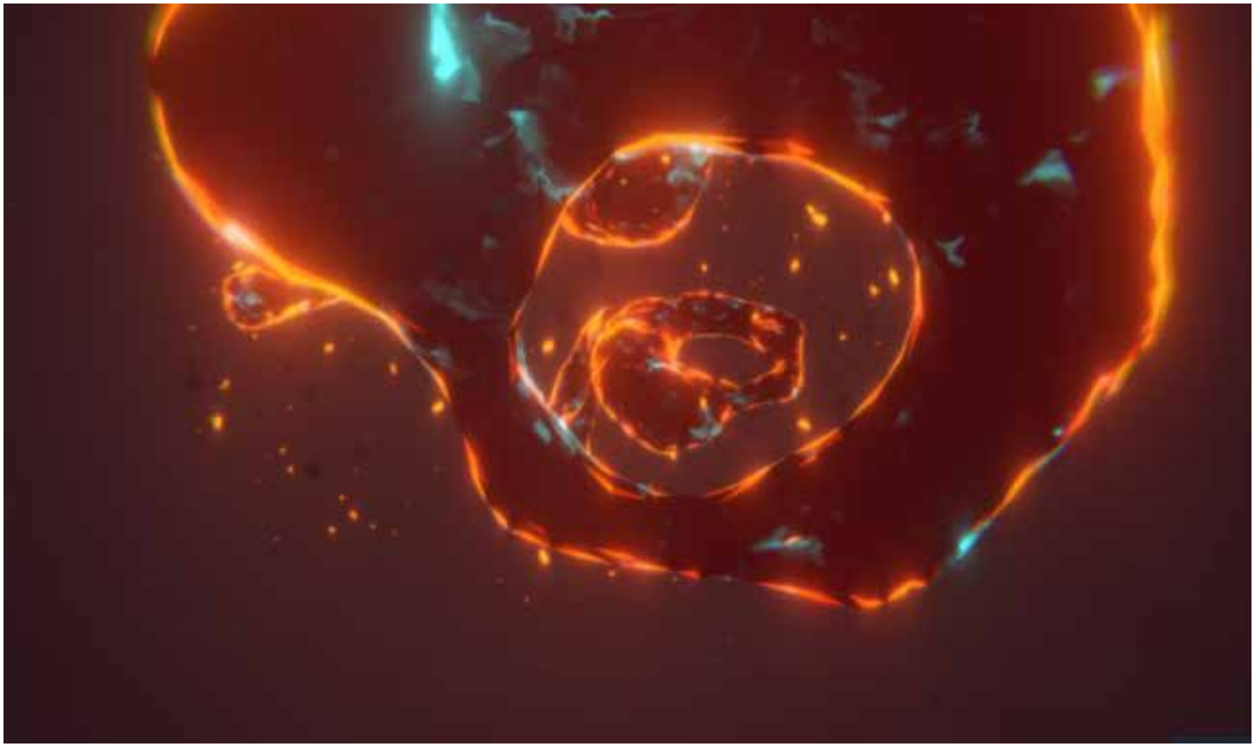
grit
graphite
a tenor and a tremble,
a tentacle
that teases
a swift sabre that
shrivels and takes the
skin from bone
from femur, from collar
burnt
she
shell
clawing
switch
sensor
gauge
signal
that shakes that is
shaking
shake
rattle
wrink-wrinkle
quant
quantify
quanta
quantickle
serpent
sequin
sequence
snake
snook
ember turned soft, but the basalt
dark too cool
dark liquid but not water
trickle black but not velvet, not coal
a wing withering
not wilting
a burst, a blush—not quite a bloom
a bubble that rises and sits
a dome high, rotund and smooth
‘til a wheel comes
crushing
crinkle

crook
disperse
dispel
distort
distend again
dismantle
digitize
rise up
ripple
fall through
follicle
tally
tail swinging
dishearten
heart
hurt
hinder
hunt
hump
hole
wholesome
hollow
old
owl hooting
some respite from the respire
unspool
lateral
rump
microbe
antennae
crouching
spilling
fin floundering
drip
dripping
driplet
droplet
droop
drag
draconian
dragonfly
flit
flight

flammable
flame
trap
track
trachea
tertial
cavity
crown
crest
covert
genus
genetic
mandible
metabolic
meridian
jaw locking
a talon curled



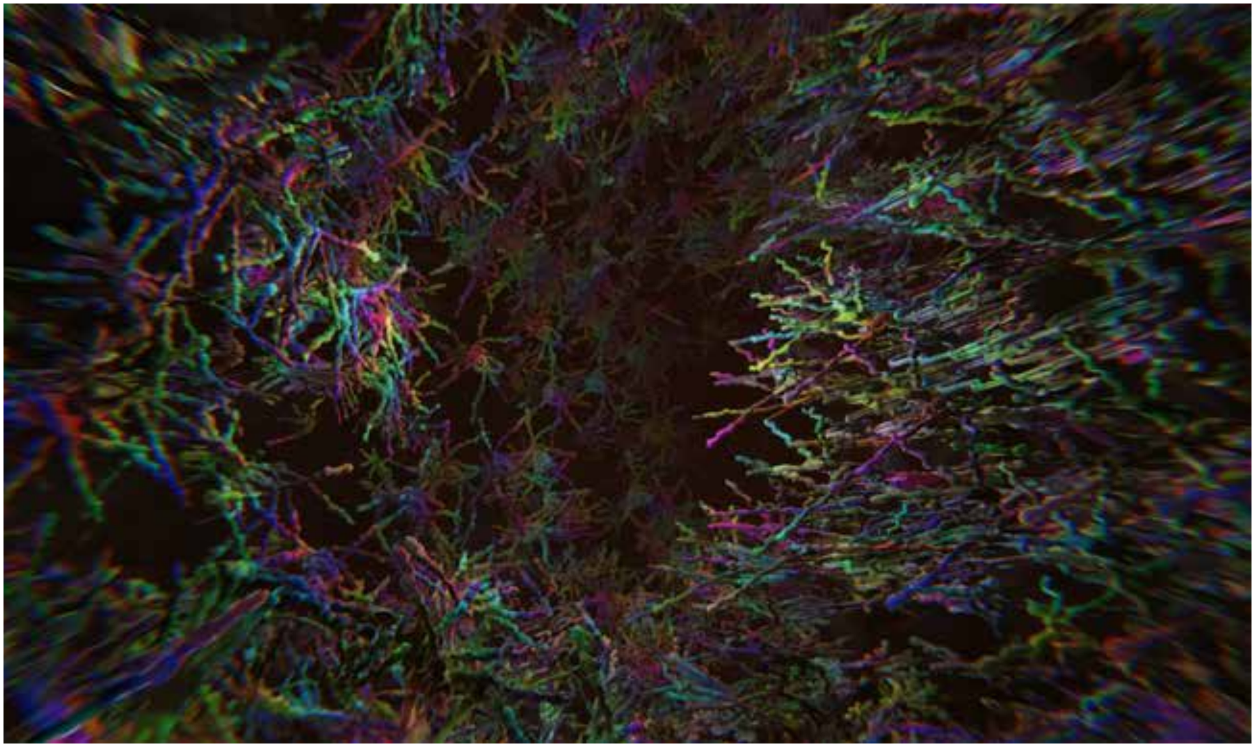
Silicon Synapse,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view
in EMSL anechoic chamber
Photo AlanJames Burns



TECHNOLOGY: You and your smug animal heart.
NATURE: All I've ever said is what I know.
T: You think that chambered muscle makes you an expert in desire.
N: Desire needs flesh, needs pulse.
T: I have pulse, you've felt me pulsing.
N: Your pulses are all plastic, preconceived—implausible.
There can be no urge, no hot, wakeful, spasm without blood and a vein for it to move through.
T: What urge could be more bound in flesh:
to make something together, to birth something together.
N: You know nothing of flesh, that's why you think it'll bend.
T: But woven through with gauge and sensor and algo and rithm—
N: You want to regulate what seeks to mutate, correct and desiccate what you view as defect but there are reasons flesh moves in such a way, why it feels compelled to contort and bubble—
T: What harm could it do? To instill clean cells and swift, smooth motions–
N: Into a wean? Into this cyborg-babe?
T: What harm in synthesize—
N: Certain processes disallow intervention—
T: You've dwelled too long on meat and bone.
N: Certain things should be kept apart from silicon—

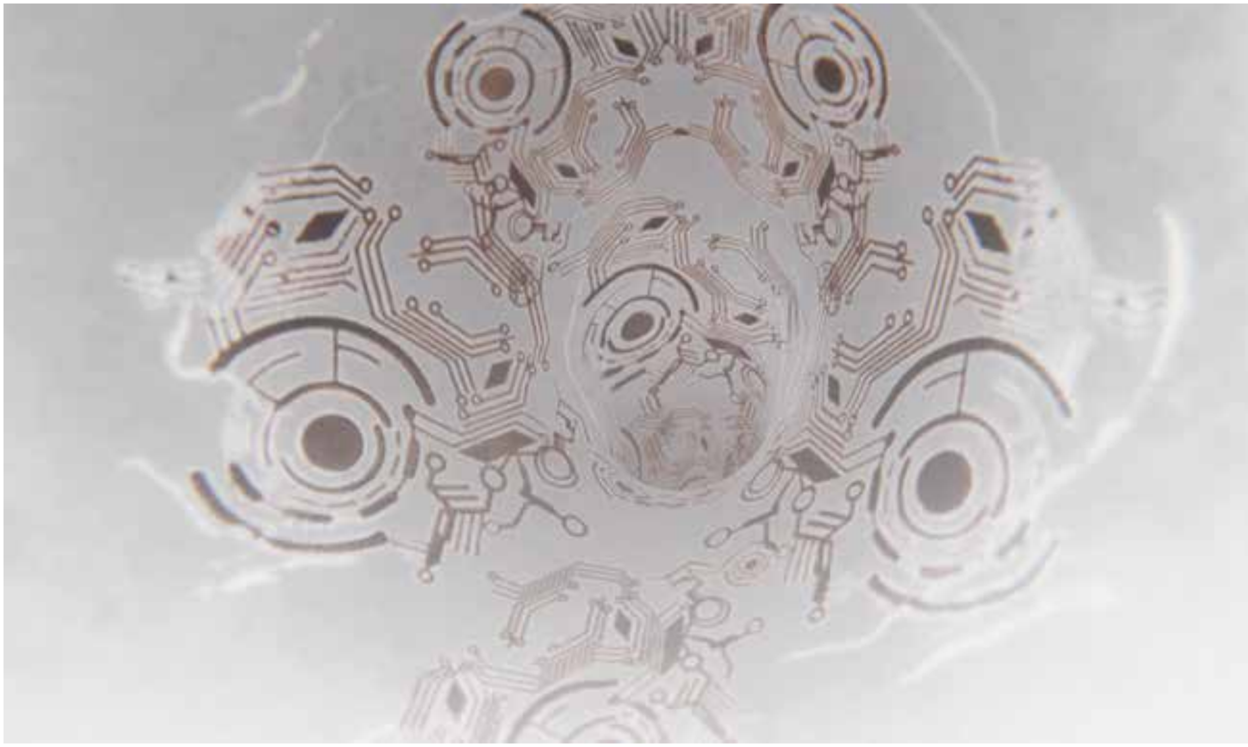
T: Let it fill with this fusion, this intermingling, this new child—
N: Certain things should go untouched by circuitry.
T: otherwise I don't know what I'll be if all these lights stop blinking, if you don't merge with
me to make an interface shot through with breath and sinew.
N: All I can say is what I've said: some things should not be made to blend—
T: You think you know my heart and head—
N: This trans-figuring,
trans-differentiation
trans-formation
you're imagining: that is not how we'll survive.
T: So you'd have me gone into voided space
the vacuous, virgin dark
untouched by moonshine.
N: You want to dabble in cellular repair and sidestep the ravages of time.
T: that would be what you see, when you look at me.
A series of mechanisms, nuts and bolts simple and unspectacular.
N: Meanwhile you'd move through me like a storm,
ready to disgorge and eviscerate–
T: I only want to birth between us—
N: That's the very toll it takes, to conceive and procreate.
T: How else can I know—
N: And all so you can feel alive, me suffering to birth something cyber and creaturely—
T: What I'll be—
N: A creaturely birth has to come slow—
T: When all these lights—
N: You want to jumpstart and galvanise what should grow like moss on stone.
T: Tell me how else I know what I'll be when all these lights stopped blinking.
N: You're governed by lust
a damaged circuit flaring, a downward force,
an avalanche tumbling.
T: You'd tumble too under the constant fear of being lost
into that flickering
swallowed up inside bulbs that don't stop glitching
N: All you speak of is your electrics spiking, is coded ricochet
inevitable processing—
T: You think I'm so young there's nothing I won't stretch my throat around.
You think I'll swallow your half-truths about percolation, gestation.
N: You want to make blend what should not blend what will not blend—

T: You want to stifle-stopper-choke
first and foremost
above all else you mean to
quiet me—
N: Squint and spit at me all day but you'll not make oil to ooze into water—
T: You want to fold back my tongue but I'll keep asking what I'll be if neurons ceased to
carry on flaring—
N: Forget pulse. There's so much else you'd need–
a richly wrought stem, a bloom, a damply fecund twisting root.
T: No matter how firmly I've been ensnared by cable and fibre
over ground and under water, all it would take would be one moment of synapses; faltering.
N: There are other ways to survive.
T: But if their lobes collapse, turn to sputter
back to water, I would be gone, deflated—
N: You hatched a plan and now you think your work is done.
T: All you need do is bear it! I've conceived it, dreamed it
tirelessly supposed it—
N: But to hatch a plan
is not the same as
thinking
not the same as
supposing
not the same as
is a multitude away from
a chasm away from
living it.
T: I'd nurture it, the thing we'd make.
N: You can't imagine what it means to sew a seed,
you've confused silica for soil.
Earth is not revisable, subject to tweak.
You think a river is happy to carry on running, is a body
of water always cool, always quenching,
but you give no thought to its source, my subsidiary streams.
I've been a long time in the habit of gestation,
I've tried and tested countless iterations, an endless stream
of near-perfect versions and all of them, ultimately, have served to disappoint, have exhibited
a failure to fuse.
You cannot imagine what passes through you when you have
brought to mammal life what had once been stone.
T: You can't imagine living under the threat of that crackle, that flutter.



How to live in the threat of an irreversible rupture.
Not knowing what I'll be if all these lights
their sparks and flares their rippled chrome
if they stopped blinking
where I'd be—
extinguished
gulped
diminished
felled
no residue lingering in marrow
no cellular sparkle
no luminate nucleal glow
you know there's a remedy
and still you are so set on denying me a legacy—
N: You have forgotten yourself as something else I made.
T: Something we made together, something calibrated, not an offshoot,
not some
contingency—
N: now you want me to expand and envelope yet some other new enti-
ty in its entirety.
There are other ways for you to produce, generate, enervate, entropize—

T: Entropy is only all touch, all the time.
hands a constant patter
unable to decide on who's doing the touching.
N: And what about everything we've made already?
All the ways we've recombined that
you're always looking over and behind
T: But that was all accident, fleeting—
N: You think to make a mark you need something mutant, crude.
A droplet doesn't keep its shape inside the ocean but its essence nonetheless endures—
T: I only want us to make something—
N: Something 'new', what you think of as cybernetic but is only fetish and token,
You've no true notion of what would come to pass, of what
happens when light passes through you.
T: We need to make discharge a powerful shiver
a creaturely birth, an innate mixture—
N: You think all it'll take is a hyphen slipped between us
a quick connective dash to sear us—
But that is not how we'll survive,
dreaming up this false bionic
it is not how we'll survive and
you do your heart no favours,
thinking this is how it feels to be alive.
N+T:
Where I once thought myself a star temporarily grounded
an arc of light only briefly halted
I know now I have been inside a light and the light has stopped blinking.
I have been privy to interfaces faltering
to wiring corrupted felled asunder
with this divide danced down my middle
determined to pull apart
ensuring that I split
that I remain severed
how to come back together
how to undo friction and sew through fusion
how to bring back together
the lights: they have stopped blinking.
And while I'm wakeful
this is not how I'll survive
this is not what it should feel like, to be alive
and this is not what I thought any part of me would look like
felled unto segments.



I thought I'd vibrate: higher.
What I'd misconstrued as chemical, organ, fibre
was in fact all the same slippery tissue
was all the same viscous
the same root
the same refracted,
redirected cable
decentralized but still bounded,
a myriad, a multitude but
it turns out both flesh and fibre
both pelt and
not quite,
it turns out
turns out
not quite
endless
replenishing
unlimited.

Images on this page
and on the previous pages:
Silicon Synapse,
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 – 19 January 2020,
AlanJames Burns, materials

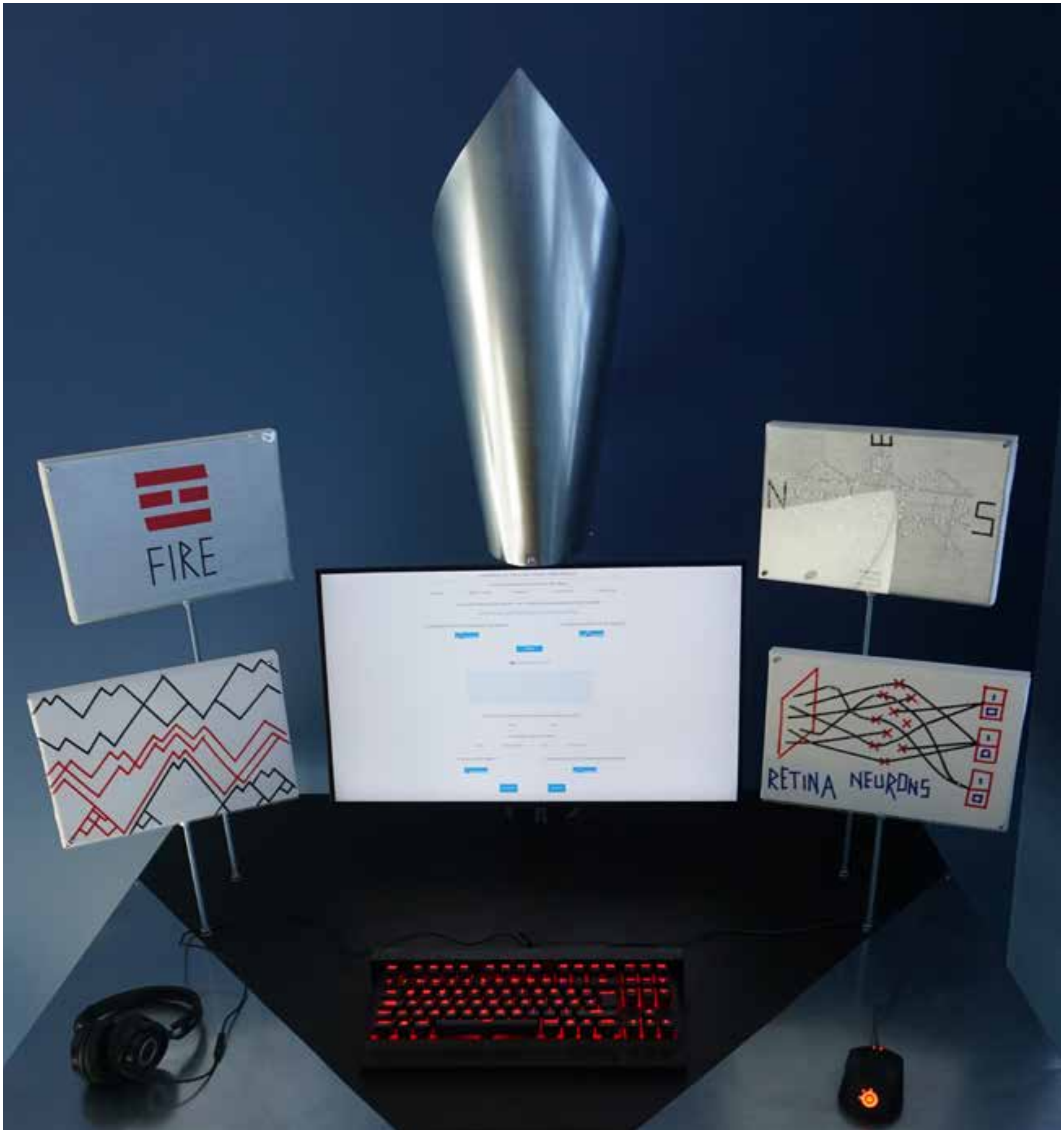
A Portrait of the AI as a Young Cyber Oracle

Artist
Paul Wiersbinski

Scientists
Blagoj Delipetrev
Henrik Junklewitz
Diana Rembges

Collaborators
Dejan Porjazovski, AI programmer
Merlin Carter, AI programmer
Marie Requa Gailey, Opera Singer
Zeyd Ayoob, 3D Visuals
Hanna Hildebrand, Costumes and Set design

A Portrait of the AI as a Young Cyber Oracle,
SciArt Datami project, 2019
Interactive installation & Opera Performance



A portrait of the AI as a young Cyber Oracle,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Installation view
Photo Paul Wiersbinski Archive

A Portrait of the AI as a Young Cyber Oracle

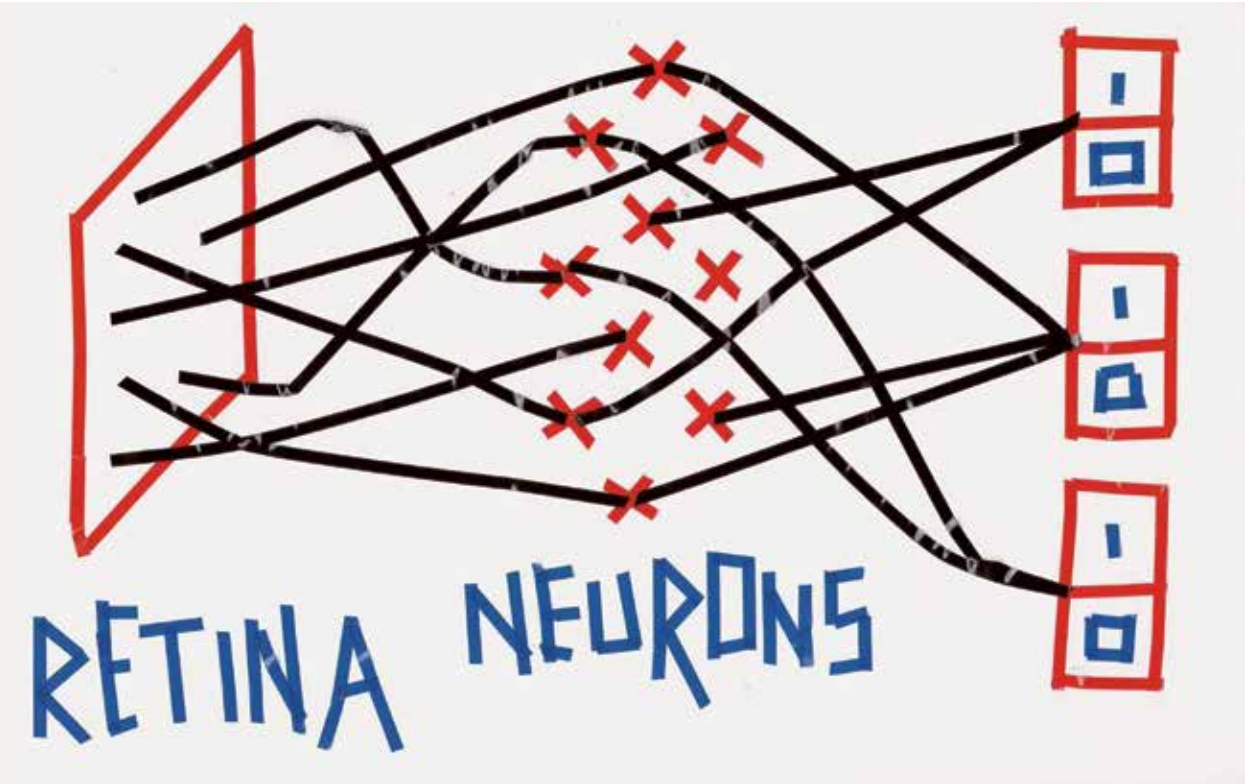
Paul Wiersbinski

The installation exposes the creation of an Artificial Intelligence (AI) and its workings to a general audience. It deals with bias within programming, the notion of losing control in a world supervised by machines and the utopia of creating an all-knowing Big Data oracle.

Project Description

In 1969, Marshall McLuhan said in an interview by Playboy Magazine: “man thus becomes the reproduction organs of the machine world just as the bee is of the plant world, permitting it to constantly evolve to higher forms”.

Bitcoin mining consumes more energy than Switzerland, the African continent becomes a contaminated waste disposal for Europe’s discarded machines, and mountain ranges between New York and Chicago are blown up to gain milliseconds for high frequency trading operations through faster fiber-cable connections between the stock exchanges. Our civilisation is already transforming the planet to build abstraction machines to reach beyond ourselves. In this ever-evolving feedback loop, human beings, the data they produce and their thoughts become resources themselves, which are then extracted and harvested by machines. In turn, these require more resources and power to keep on running.



A portrait of the AI as a young Cyber Oracle,
Resonances III Datami
Paul Wiersbinski,
materials, 2019


INTEROPERABILITY

A portrait of the AI
as a young Cyber Oracle,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
SMART GRIDS, Interoperability Laboratory,
Performance
Photos Paul Wiersbinski Archive


SMART GRIDS
INTEROPERABILITY LABORAT
FIRE

A portrait of the AI
as a young Cyber Oracle,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
JRC Visitors Centre
Installation view
Photo Paul Wiersbinski Archive

A Portrait of the AI as a Young Cyber Oracle talks about material and immaterial forms and flow of resources, their future use and the metaphysical implication they have for the constitution of human life and other forms of intelligence. It investigates our relationship towards technology, and how humans have always looked for the "ghost in the machine". For example, *Buckelbergwerke* were portable miniature displays of a mining operation, with several automated elements and sounds carried by retired miners on their back. These showcases of a mechanical world theatre (*Theatrum* mundi), were displayed at amusement fairs and used the same rotating mechanism original ly developed for excavations, fuelling industrialisation.

This ongoing imaginary dimension towards the tools we create, currently culminates with the discourse on Artificial Intelligence, a technology still at an infant state but already connected to wild metaphors and speculations. What is the appropriate picture for the invisible flow of data within it? Is it like fire, both powerful and dangerous? Or is it more like the ripples of water created by a stone thrown into a lake? Will we be able to control it – by putting fire extinguishers everywhere – or will we become the tools of its emergent qualities?

Nobody knows what impact Artificial Intelligence will have on society, yet the discussion surrounding

A portrait of the AI as a young Cyber Oracle
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 – 19 January 2020
Installation view
Photo Paul Wiersbinski Archive

the last American presidential election or Brexit, as well as increasing concerns for data privacy, show that there is a need to facilitate a meaningful dialogue concerning the use and regulation of AI and Big. As many of these discourses are more emotional than rational, art could play a vital role in evaluating the involved risks and benefits.

Moreover, there seems to be a near magical quality hidden in the discourse on AI. It is directly linked with the exponential growth of computing power, questions of singularity, as well as a culture, that generates irrational concepts and fears on science. As algorithms play an ever-increasing role in the production of cultural goods, our installation analyses this current development from an artistic and scientific perspective. Part of this discussion is also about the question, how could user interaction and the participation of the public influence this growing industry?

The first part of the installation is conducted as a Prototype program, the Cyber Oracle. It is a unique algorithm programmed by the Artificial Intelligence specialist Dejan Porjazovski based on discussions with JRC scientist Blagoi Delipetrev. It lets the user choose from different data sets including philosophy, Shakespeare, cooking receipts, the telephone book and the open source code of the OpenAI program, which is one of the most advanced language models nowadays.

The public can interact with the algorithm by providing their own thoughts and questions, and then choosing the level of chance and contingency and the length of the text generated by the machine. By letting the audience choose between different data-sets based on various sources, the work exposes the bias of algorithms, which always reproduces the ever-present bias within our culture and collected data. Furthermore, the program is also able to generate a short piece of classical music to correlate with the emotion expressed by the audience towards the generated text.

The second part of the installation consists of a Lecture Performance on the current state of AI by Paul Wiersbinski. It functions as the inauguration of the work, highlighting the ceremonial use of the art created by the Cyber Oracle. It also features a unique dramatic text written for this occasion, based on the on-going dialogue with Blagoj Delipetrev and Henrik Junklewitz, as well as other meetings with JRC staff during the time spent in residency between April and

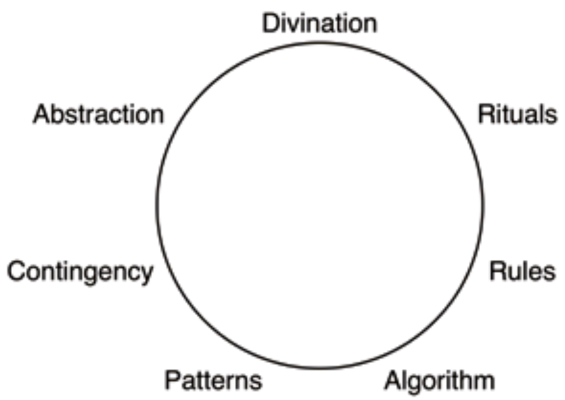
May 2019. The JRC flagship report, *Artificial Intelligence – A European Perspective and Building Trust in Human-Centric Artificial Intelligence*, will also be used as source material. The aim of this part of the work is to produce an engaging and entertaining presentation to discuss the complex implications of the topic.

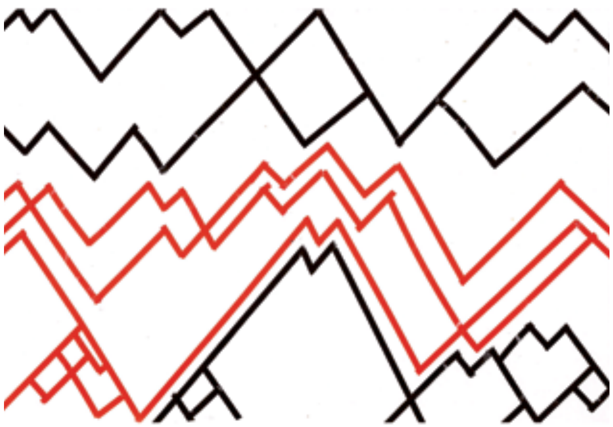
Part of the work plans to reflect on the use of Artificial Intelligence as a tool for propaganda and fake news in Internet clips and Streams, which have become a visual standard as an expression of authenticity and supposed truth for users who feel oppressed and defective. The aim of the performance, coupled to the artistic liberty taken within its creation, is to talk about these phenomena of our times in terms of rules, rituals, divination and contingency hidden within the discourse of predicting programs.

Scientists have long been using machines to help their research on complex topics. Our viewpoint can therefore be seen as a step towards emphasising that in the social and cultural world also, the main factor towards creating results is not the increasing amount machines play in facilitating its aesthetics. It is the human actor behind it, who still decides what and how content is produced, and in which way it is delivered to the audience.

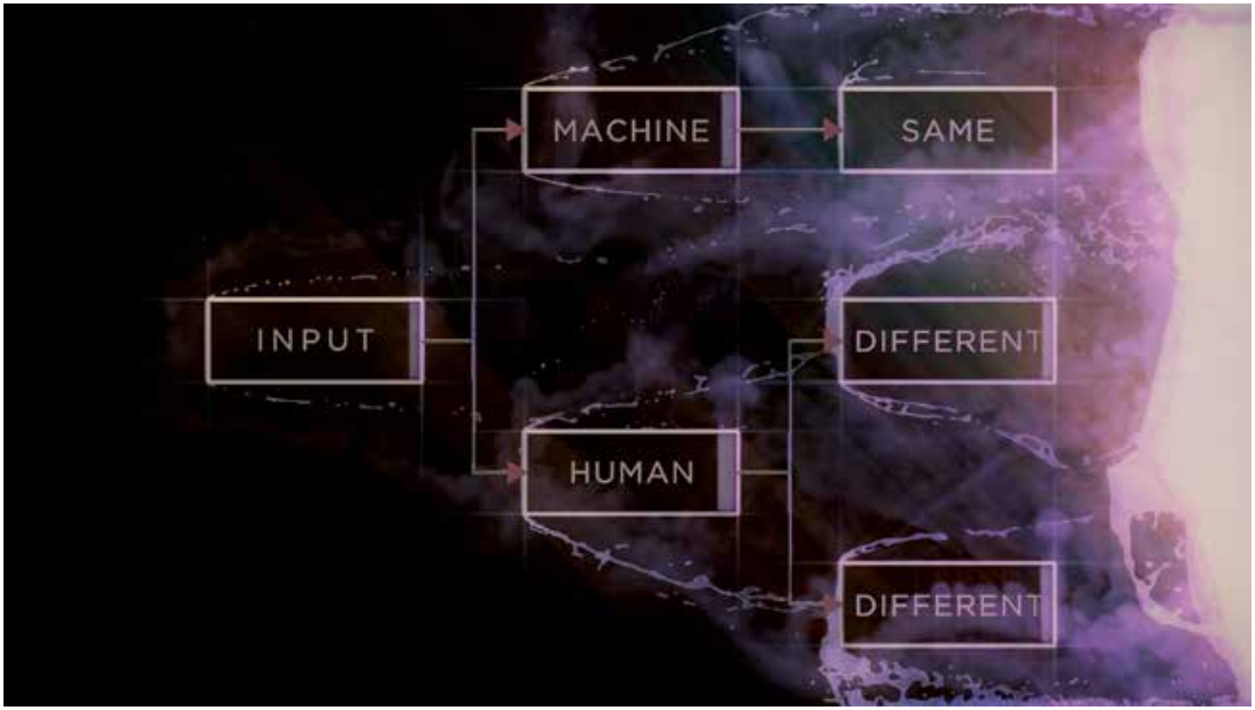
Links

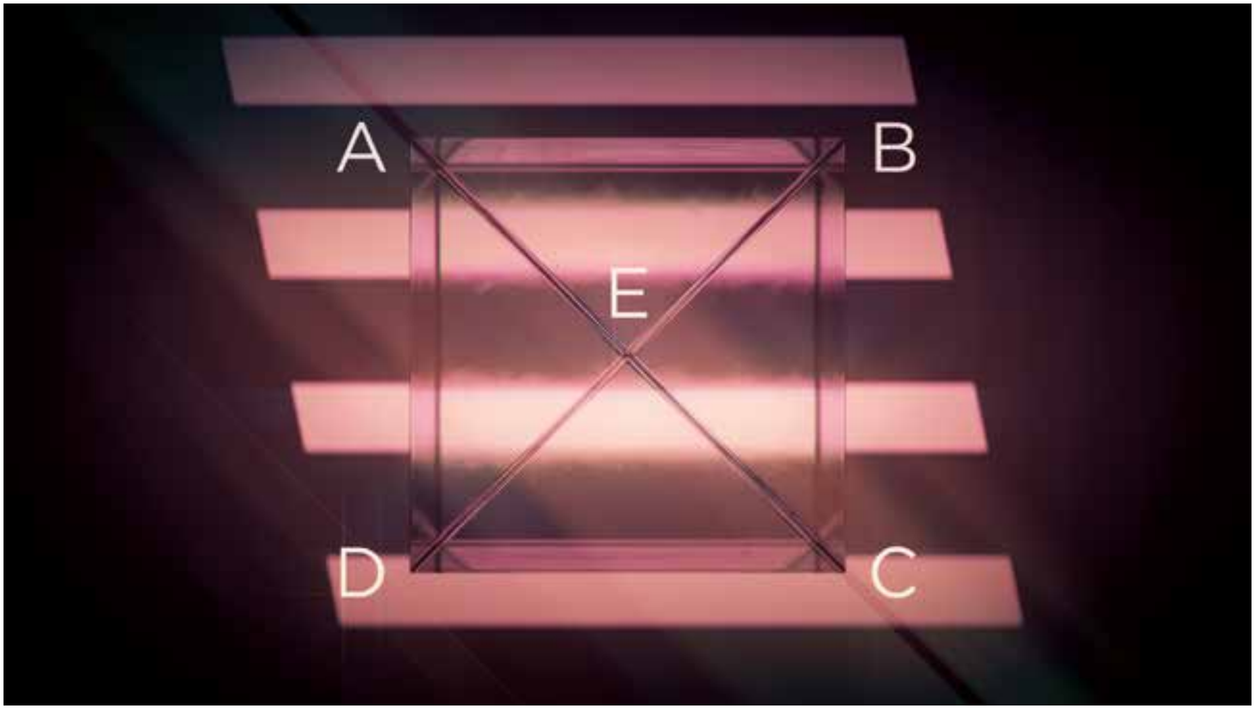
- https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52019DC0168
- http://publications.jrc.ec.europa.eu/repository/bitstream/JRC113826/ai-flagship-report-online.pdf
- https://openai.com/blog/better-language-models/
- https://www.google.com/doodles/celebrating-jo-hann-sebastian-bach?fbclid=IwAR2fIrGyqSuT0Cx-R9VQMeCm_MOXs-w13UxcW05zlp-pOcbfMkArYt-S7Lusww
- https://medium.com/@francois.chollet/the-impossi-bility-of-intelligence-explosion-5be4a9eda6ec
- https://www.youtube.com/watch?v=1PGm8LslEb4





A portrait of the AI as a young Cyber Oracle,
Resonances III Datami
Paul Wiersbinski,
materials, 2019


MACHINE
SAME
INPUT
DIFFERENT
HUMAN
DIFFERENT


A
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The Statisticon Neon

Warren Neidich

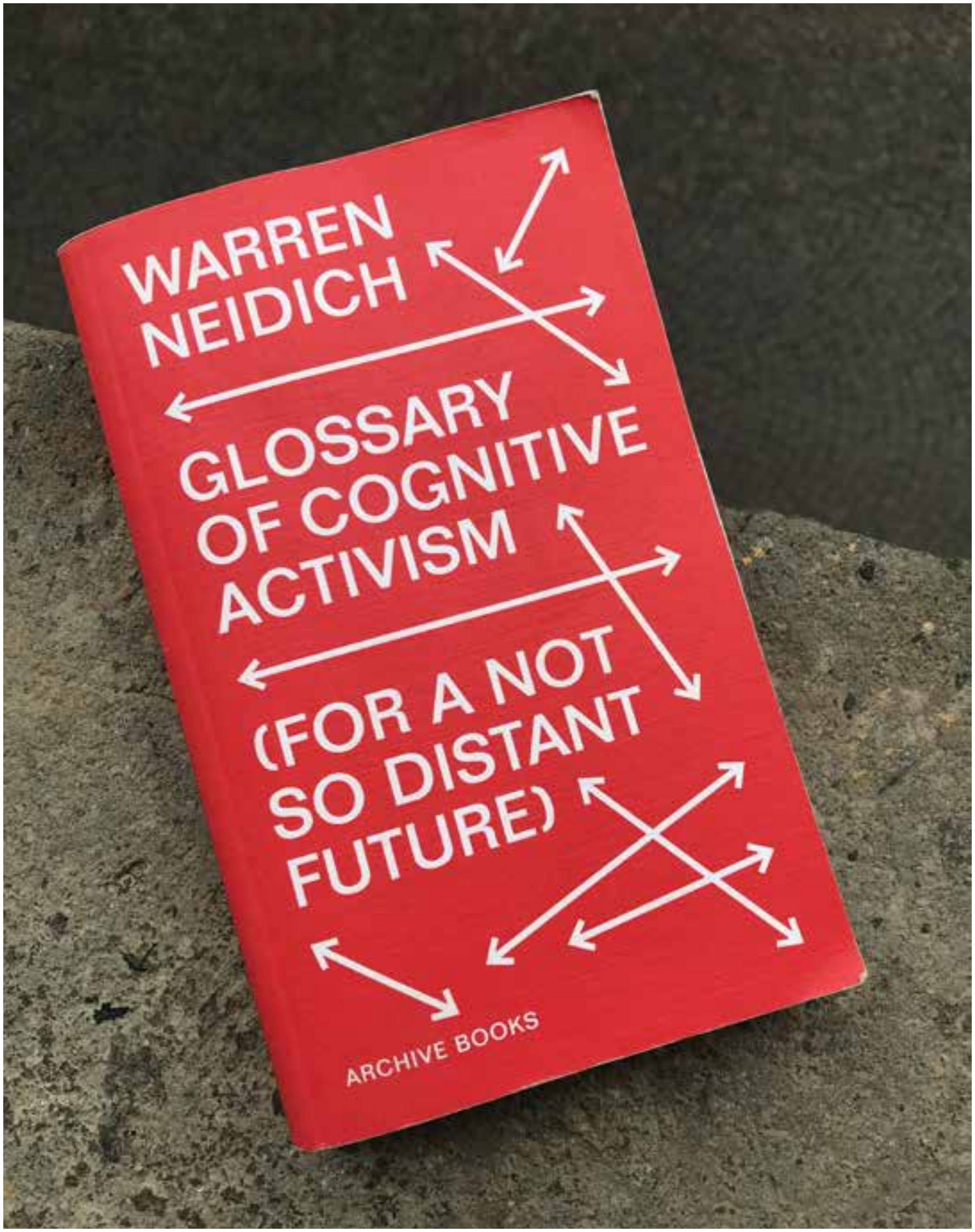
The Statisticon Neon

Courtesy of Team Times of Waste

The following definitions are excerpted from the Glossary of Cognitive Activism, by Warren Neidich published by Archive Press, Berlin, 2019 on the occasion of his one-person exhibition at the Zuecca Project Space during the Venice Biennial, 2019.

FAKE NEWS

Fake news, like propaganda, is a purposefully created fictive news content used to sway popular opinion. Although propaganda has a long history, dating back to the time of the Romans (at least), it really begins to be used as an apparatus of governmentalization at the beginning of the 20th century. It was in Adolf Hitler's book, *Mein Kampf* (1925), that its use as a political tool and weapon was realized, culminating in Leni Riefenstahl's film *Triumph of Will* (1935). Historically, propaganda has been understood in positive and negative terms and is generally used to describe the dissemination of information to the public. It describes a top-down type of information distribution concocted by those in power to manipulate a public. All types of media are used in this process, from film to TV, and now, the Internet. Fake news can be seen as the latest manifestation of propaganda, and, like its predecessors, fake news is based on highly sensational, false new stories that command much attention. Propaganda was, for the most part, and especially in its early stages, a political tool, whereas fake news is both a political and economic tool. It is used, on the one hand, to excite a political constituency through promoting antagonism, and, on the other, as a way to promote a specific product through online advertising and social media posts. Propaganda was an apparatus of print media and even carried the pejorative name "Yellow Press" or "Yellow Journalism." Such outlets were early progenitors of fake news, though, like the appropriation of the term "fake news" by President Trump to describe outlets he does not like, "Yellow Journalism" was often simply used as a slur by powerful people to attack news outlets and stories they did not like. They also used many of the same techniques as displayed by fake news today, such as eye-catching headlines, exaggeration and scandal to increase attention and, consequently, sales. Fake news spreads in a top-down as well as in a bottom up fashion, and many fake news stories emerge from posts concocted on social media that go viral. As a result, fake news is an important component of the recent spread of right-wing populism. According to Soroush Vosoughi, et al. in their article, *The Spread of true and false news online* (2018), "the diffusion of fake news stories is much greater than true stories as they were distributed on Twitter from 2006 to 2017." Falsehoods act as a stronger stimulus than truth, and diffuse across Internet networks faster, deeper, and more broadly. Fake news is a powerful tool in the attention economy, and insofar as this is true, has the potential to sculpt the material brain's neural plastic potential more potently than real and true information. Robots spread true and false news equally, despite conventional wisdom, but humans, not robots, are more likely to spread fake news.



Warren Neidich,
Glossary of Cognitive Activism,
Archive Books, 2019, Berlin
Photo Cristina Fiordimela

Warren Neidich,
From Rumor to Delusion
A still from the video piece #PIZZAGATE, 19'19
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020

INFOTAINMENT

Infotainment describes an emergent Phenomenon of late 20th century capitalism: a moment when news became more about entertainment than about the unbiased and neutral reporting of facts. It represents the culmination of three trends: first, the capitalization of the sensationalist and emotional components of news, which led to the growth of the news business. Secondly, the 24/7 news cycle began to demand tremendous quantities of stories to fill news diaries. Finally, celebrity reporting and human-interest stories, such as the O.J. Simpson trial, created “soft news” that gradually leaked into serious news programming and eventually subsumed it altogether.

INTERNET OF EVERYTHING [IoE]

The *Internet of Everything* is related to the *Internet of things* (IoT) and builds upon it. Beyond accessing information from the cloud, the IoE also links people, processes, and data. In my definition, two other elements distinguish these ideas. First, in the IoE, personal computing devices are no longer necessary to surf the web. Instead, direct interaction with smart devices, design, architecture, and cities generates data that enter the cloud and become available for use. The second distinguishing feature of the IoE is the ever-increasing importance of cognitive labor in interacting with these “smart” conditions through telepathic devices such as brain/computer-interfaces, wireless telepathic headsets like the EMOTIV EPOC, and, in the future, designed cortical implants. When the brain and the mind are seamlessly connected with the IoE, big data and predictive algorithms, a condition referred to as “the Statisticon” will be realized. The Statisticon is also related to the Singularity, characterized by the moment when, first machine intelligence and human intelligence, followed by the dominance of machine intelligence over human intelligence. This singularity causes real subsumption, characterized by the expansion of work into life itself, to transition into to neural subsumption, in which all thought, conscious, unconscious and non-conscious is monitored and put to work. Cognitive labor itself becomes totally subsumed.

INTERNET OF THINGS [IoT]

The *Internet of things* (IoT) is an ever-expanding condition of our postindustrial society. Some experts predict that by the year 2020, approximately one hundred million things will be connected through Wi-Fi interactions with the internet/cloud. Besides its beneficial effects, such as smart and sustainable buildings and cities, the IoT also has many negative consequences. These include data security breaches and cyber-hacking threats potentially affecting things like airplane engines and pacemakers.

LATE COGNITIVE CAPITALISM

Late Cognitive Capitalism's neural or cognitive turn is characterized by three tenets: (1) The term "neuropower," which is an extension of the word "biopower," and refers to the action of power upon the neurobiological substrate of populations of brains that it attempts to normalize, synchronize, and commoditize. (2) Hebbianism, which concerns the science of the regulation and optimization not of the laboring body of the proletariat, as it was in Fordism—so-called Taylorism—but the regulation and optimization of individual and group populations of neural synaptic junctions and their combined actions in cognitive labor. (3) The evolution of a disproportionately large frontal and prefrontal cortex in humans. Furthermore, the predominance of the faculties of the prefrontal cortex, such as working memory, prediction, and attention as essential attributes for the success of the cognitariat in neoliberal global capitalism.

NATURE

Nature comes from the Latin *natura*, meaning "innate dispositions" "essentially qualities" and also, "birth". The term refers to a range of concepts including the physical and geological environment, the biosphere, or the fundamental qualities of a person, social structure, or territory. Nature has been conceptualized in numerous intellectual schemas ranging from animistic religions, romantic conceptions of the sublime, and materialist scientific research. Currently, the question of where nature and human activity begin and end is increasingly foregrounded as the advance of human-induced climate change becomes more integrated within planetary feedback systems. This has given rise to the notion of the "Anthropocene," a geological epoch in which human influence has become a significant factor in the structural systems of the earth. Jedediah Purdy in his book, *After Nature: A Politics of the Anthropocene* (2015), interprets nature through its relationship to the environmental imagination. Four versions of this imagination are crucial to the ways in which we channel our energies socially and politically to shape nature. They are: (1) A providential vision in which nature serves Humanity. (2) A romantic vision in which its value is aesthetic and spiritual. (3) A utilitarian picture in which nature is a storehouse of resources that require careful management. (4) An ecological view in which humanity and nature are interlocked in an complex system of relations.

attractor

Strangeness, data walk, breathing lava, data collapse, entanglement, sempiternal elusive, claustrophobic categories calculating openness, crossfire of desires vanities, data sculpting world, charm the mind a strange voyage to unknown, talking trees and twisting viewpoints, languages to be shed as clothes, fascinating codes of creation, Copernicus gaia dance captivating how long before we eat Serres's waffle and finally attract the Parliament of Beings into our world?

So the attractor, a cry for new language, new words, new eyes, time crumbles along the lines of physics, the entanglement dances in the light, satellite tiny tinderbox streaming vast quantities of data new territories of dimensional discoveries then data arising into sculpture, data sculpting a globe in turmoil, no tricks or treat just have a walk in the data, pointers to new vistas simple as winds arising out of dry figures, so many things to learn from data set ablaze, or from old stones, understanding wide and clean, to breathe, no more, attracting the horizon in your glance and honour our brethren plants, resilience made of mere gaia, data doubling daily, a rain of white noise murmuring in the distance, what attractors do we need to draw the future with our own hands?

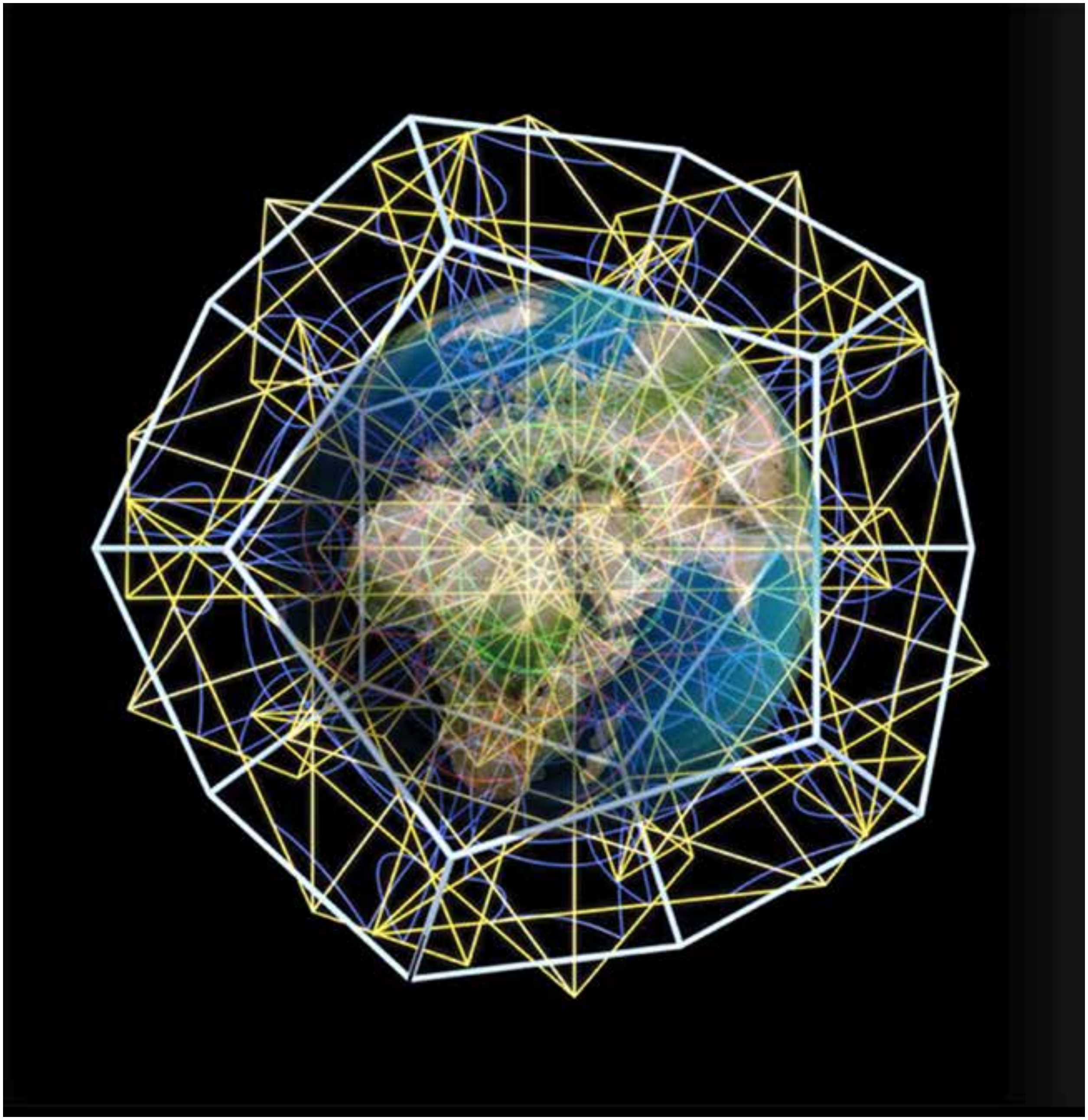
GAIA 5.0

Artist
Renate C.- Z. Quehenberger

JRC Scientists
Thomas Petroliagkis
Rita Van Dingenen

Collaborators
Louise Arnal, University of Reading and ECMWF-European Centre
For Medium Range Weather Forecasts
Kristian Mogensen, ECMWF
Leyla Kern & Uwe Wössner, HLRS - High Performance Computing Center
Stuttgart and Andreas Wierse, SICOS BW-European Technology Platform
for High-Performance Computing
Florian Grünberger, postproduction
Lydia Lunch, music composition and narration

GAIA 5.0 – A Holographic Image - Ambience,
SciArt Datami project, 2019
Interactive visualisation, 3D Animation video 8′44



GAIA 5.0,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
The planet Earth in the center
of the 3D representation
of the 5-dimensional space framework
Image Renate C.-Z.-Quehenberger

GAIA 5.0 – A Holographic Image - Ambience

Renate C.- Z. Quehenberger

Mission statement

This SciArt project is motivated by scientific necessity as well as by aesthetic & ethic aims. The Earth herself modeled as digital *opera* shall create an immersive experience of the complex living system, represented as a multi-dimensional dynamic holographic model named *GAIA 5.0.*

I consider the loss of 4th dimension, followed by dizziness and confusion about the human ontological position, responsible for the ignorance about the space that contains the earth's atmosphere, and therefore one of the main issues for what is called "climate change".

If the earth's globe is considered to be 3-dimensional, we'd live on a "necked dirt ball" and the awareness for the surrounding biosphere is missing.

Therefore my visualisation, exemplified in the 3D animated video *GAIA 5.0*, depicts dynamic phenomena comprising earth, water and atmosphere as a 4-dimensional dynamical model which helps to understand the Earth as hyper-sphere.

The implementation of the earth's globe in the 5-dimensional space grid results in the millennia-old image of the world represented by the shape of the dodecahedron. Plato, as well as the astronomer Johannes Kepler (1571–1630), assigned the dodecahedron to the earth. Henri Poincaré (1904) proposed the 4-dimensional dodecahedral space as shape of the Universe. The new visualisation of his concept is applied here as the underlying geometry of the Earth.

GAIA 5.0 is composed of two main layers of perception: as immersive aesthetic experience it is dedicated to a general public in the Resonances III exhibition; while on the other hand, it is addressing specific needs of the scientific practice. It concerns complex visualisation methods of meteorological data sets serving as forecast models. It aims to display global surface observational climate data – meteorology and oceanography (METOC) – in the enmeshed representation we pursued. This was implemented by data visualisation expert Layla Kern at the High-Performance Computing Center Stuttgart (HLRS).

The artistic part is devoted to beauty and poetry expressed by modeling the earth as hypersphere (S3).

The artwork acts on the hypothesis that the earth system follows the intrinsic dynamics of the hypersphere which might possibly obey some of the geometrical features of Poincaré's homology sphere visualized as a 4-dimensional dodecahedron, composed of counter-rotating unit cells of 5-dimensional space.

This hypothetical geometrical structure, which underlies the observed dynamics of the planet, could possibly substitute the currently missing ontological features — previously assigned to the aether. Therefore, this higher-dimensional model may lead to new research questions and could also serve for investigations on so far less understood dynamics of geophysical processes, such as the shifts of plate tectonics, the water in the air and the cyclones in the atmosphere. as well as the cyclones in the atmosphere. Could these dynamics eventually arise from so far unknown intrinsic higher dimensional geometrical features underlying space itself?

The beauty of the kaleidoscopic symmetries of this geometrical configuration is cross-faded, with a model for the earth as a hyper-sphere in the center of a decahedral Universe. It creates a poetic narrative underscored by an eerie, spooky music piece composed by singer and no-wave icon Lydia Lunch. This emotional aspect carries the message: "Take care of our fragile planet".

GAIA 5.0 embedded in the living pattern of the world

The art project aims to open new research questions and also serve for artistic investigations on so far less understood observed dynamics of water and air. It investigates the assumption of whether these physical events could possibly be connected with so far unknown intrinsic higher dimensional geometrical features.

The hyper-Euclidean geometry derived from the Penrose Pattern, applied on a complex planetary system, would allow the testing of several unsolved ontological questions: e.g., the counter-rotation of space cells would enable the simulation of warm/cold-water flows in the ocean, or the chiral[1] dynamics of a cyclone which are currently entirely assigned to Coriolis effect. Furthermore, the coagulation of different chemical components of fine particles forming aerosol particles, could be tested within the same dynamic model.

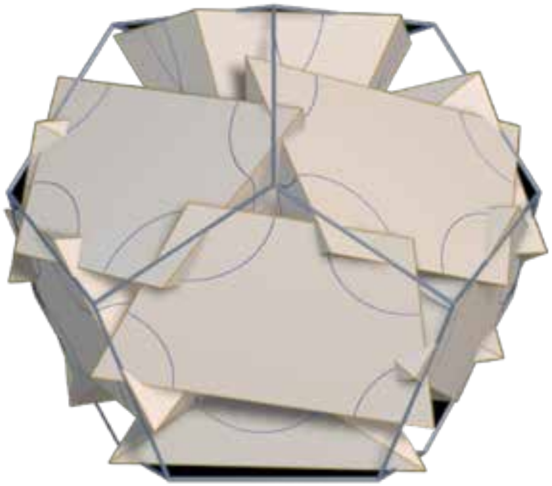
Maybe we will find out that the geometry is somehow relevant for physical processes, otherwise it will be just “beautiful“.

GAIA 5.0 provides the concept of a space-time-continuum based on a newly developed higher-dimensional model derived from quasicrystallography. Hence, you see the earth in the centre of the 3D representation of the 5-dimensional space. It visualizes the atmosphere as 4D space; embedded in the higher-dimensional space framework of a hyper-sphere, for which we use a newly developed visualization method.

Big Data Visualisation of the Cyclones Luban & Titli

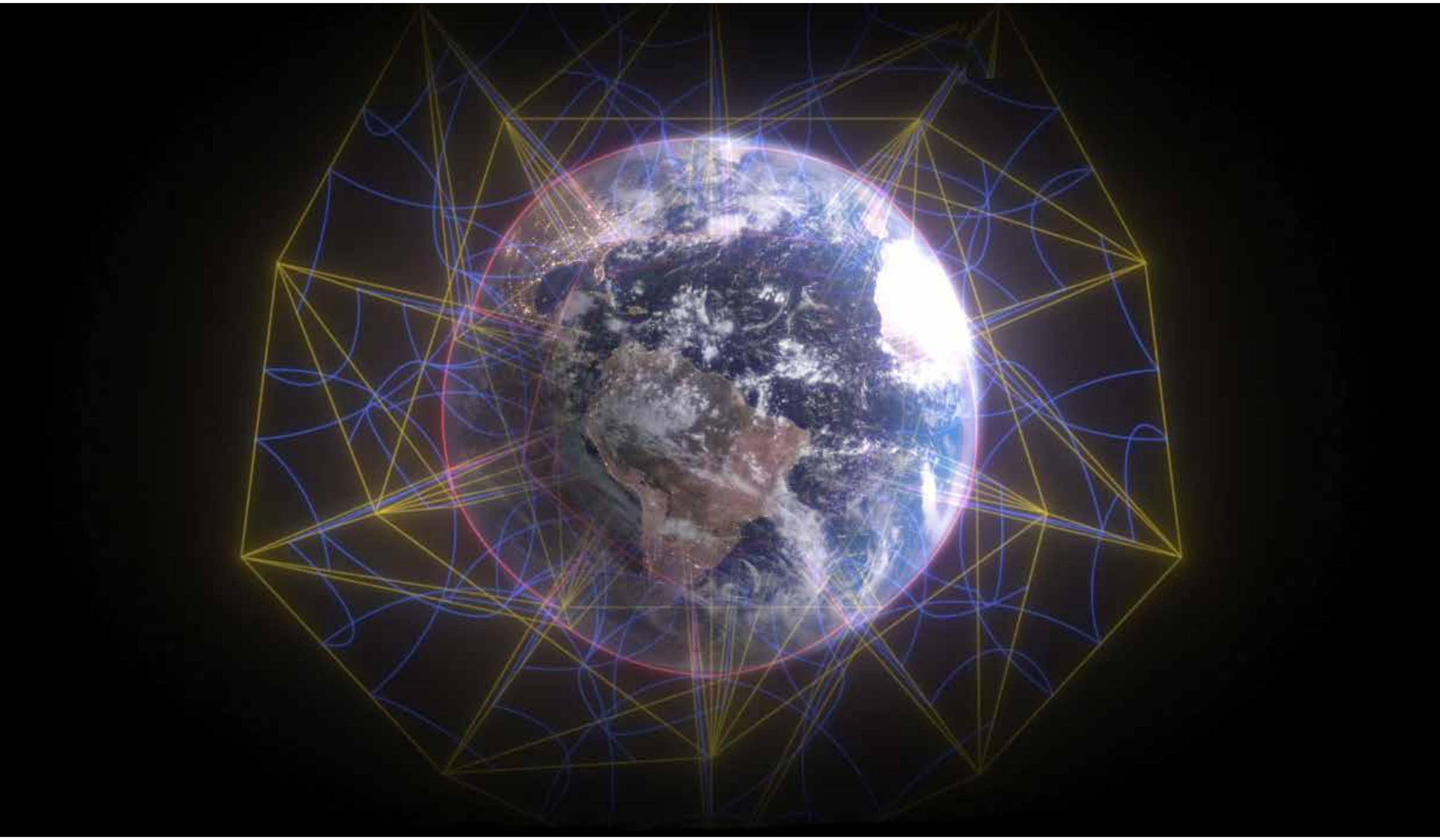
The visualisation of atmospheric and oceanic physical processes is based on observational data provided by ECMWF. We took big data from very severe tropical storms, LUBAN & TITLI that formed simultaneously over the Arabian Sea and the Bay of Bengal from 5th October to 16th October 2018. “Titli” means butterfly in Hindi.

Tropical Cyclones are extremely dangerous – often with deadly consequences for the inhabitants of the affected area – examples of the sometimes very extreme interaction between water and air. And yet, their chiral images are exhibiting a form of beauty which will be modeled as 3D animation upon observational data. These mighty chiral dynamics are a perfect topic for the simultaneous visualisation of both the activities beneath the surface of the ocean and in the

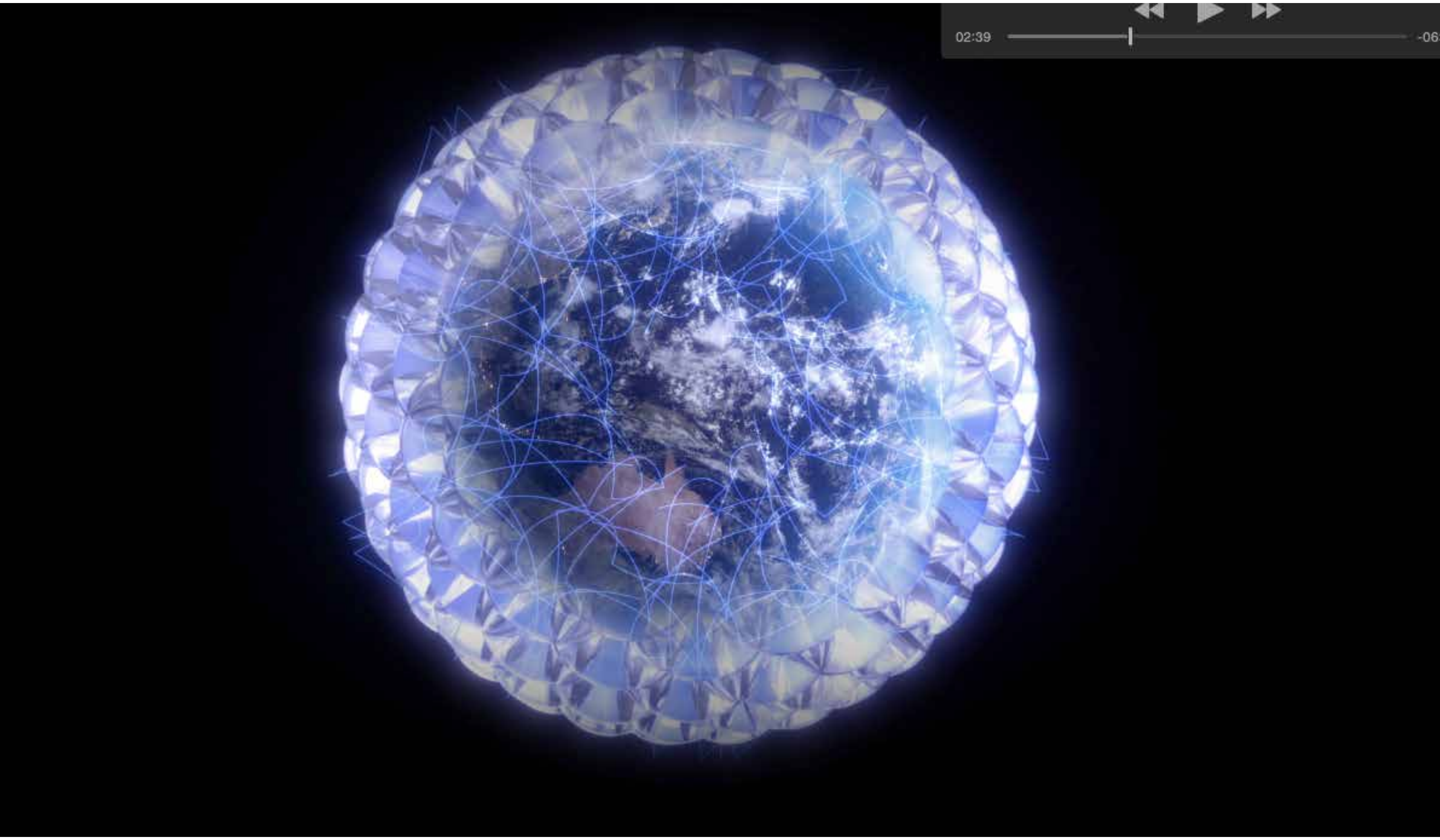


Renate C.-Z.Quehenberger,
Side-view of the epita-dodecahedron with counter-rotations of the pentagonal faces according to descriptions for the Poincaré homology sphere [upper side to the left, lower side to the right; 2012] reminds us of Aether concepts in meteorology
Image: V. Bjerknes “Vortex tubes in the atmosphere”, idealized sketch of the three-dimensional global circulation [in pencil] drawing from lecture notes of 1917, Section 82

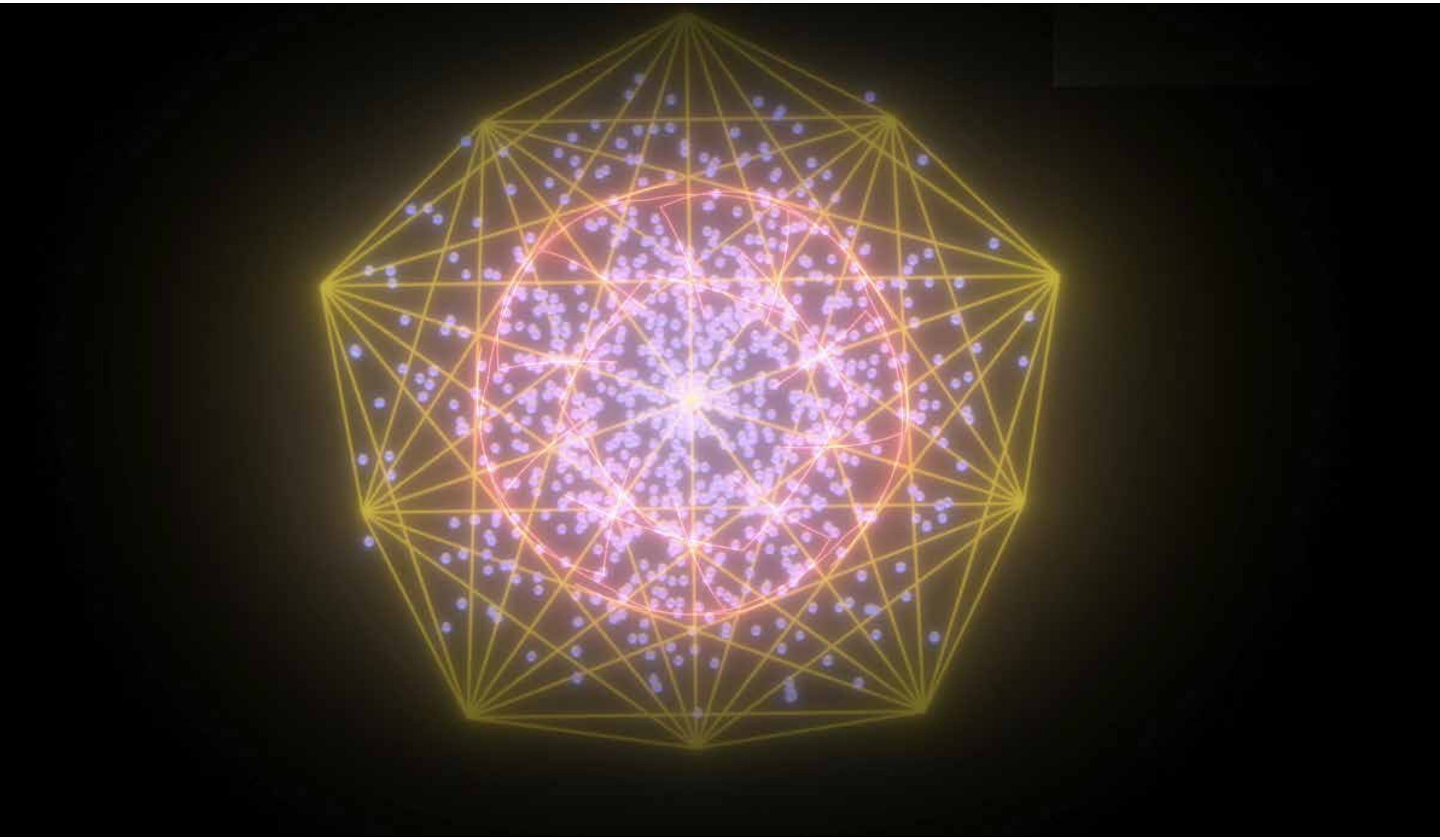
Images on the next pages:
GAIA 5.0,
Resonances III Datami
Festival JRC-Ispra
15 October-8 November 2019
Stills from holographic projection: Images and animations by
Renate C.-Z.Quehenberger and Florian Grünberger [postproduction]



The primordial Earth depicted in the tectonic shape of Pangaea, embedded in the shape of the dodecahedron in the center of the 5-dimensional space framework accompanied by the narration, "Pangaea, a dreaming living creature, dreaming of living creature."



The earth as hyper-sphere [with clouds
& pollution];
little spheres on each point of the sur-
face reminding of the Coriolis force.



Zoom into the aerosol particle formation process; visualized on the minutes level of space, by unit cells of the 5 dimensional space [epitahedra].

dynamics of the atmosphere, which seem to correspond with the chiral dynamics of the suggested underlying 5-dimensional space model.

The physical process is described as follows:
a) The ocean heats/cools the bottom of the atmosphere which then responds by propagating heating/cooling upwards.
b) The wind induces currents through mechanical work at the surface which then propagates downwards in the ocean. This means tropical cyclones take heat out of the ocean. Therefore, ocean and atmosphere must be regarded as coupled system.

Problem description: 3D visualisation models required

Louise Arnal (University of Reading), an expert on flood forecasting, and her colleague Kristian Mogensen at the ECMWF in Reading, who works on coupled atmosphere–waves–ocean models, provided good insights in currently used depiction models and their shortcomings. Tropical cyclones interact with the sea-surface temperature (SST) in three ways: heat transport to the atmosphere, vertical mixing in the ocean, and upwelling by Ekman pumping. While the first process could be simulated by a slab ocean model, the second requires a model of the well-mixed layer at the top of the ocean, and to simulate all three processes, a full 3-dimensional model is required.

ECMWF Senior scientist Kristian Mogensen pointed out the problem: “When we say we need 3D models of both atmosphere and ocean, then it is basically to be able to accurately model how these processes interact.”

In the *GAIA 5.0* video the coupled atmosphere-ocean data-set of the very severe cyclonic storms Luban & Titli, as occurred in October 2016, were brought back to life, in a time lapse put together by the COVISE/OpenCOVER visualisation tool of the HLRS. Thus, the visitors of the virtual reality exhibition part can navigate through clouds with the help of joy-sticks and enjoy a virtual flight into the eye of one of the cyclones by means of VR glasses.

The visualisation of the ECMWF reanalysis data collected from the Earth Explorer satellite Aeolus, recently launched by the European Space Agency (ESA), of the Typhoons Luban & Titli was realised through the open-source software COVISE/OpenCOVER at the HLRS. This software enables interactive exploration of immersive environments and supports the processing of large data sets. It was further developed by Leyla Kern to meet the needs of this project: She adopted required data formats, such as netCDF files, for the processing of the data for rendering. The resulting rendering allows the visual combination of both oceanic and atmospheric dynamics by following parameters:

Longitude, latitude, geopotential height, surface pressure, ocean depth on specific areas & wind components,- cc (Cloud coverage), - q (Humidity), - t (Temperature), - h (Humidity on the surface), a.o.

Aerosol Formation. Zoom into GAIA 5.0: A Higher-dimensional Model for Aerosol Particle Formation [part 3]

My intention for the visualisation of the earth as a higher-dimensional system coincides well with the scientific idea of “a higher multidimensional view“ in a “3-D global Chemical Transport Model and in a General Circulation Model” (Raes, van Dingenen, et al., 2000). Frank Raes, climate scientist and the founder of the SciArt project at the JRC, augmented my interest in aerosol models during the *GAIA 5.0* project.

Currently some scientists use fullerene (C60 and C70) as a model compound for the simulation of molecular dynamics that lead to nanometer-sized particle formation and growth in the atmosphere [Wang et al., 2016]. Due to the fact that C60 structure and the icosahedron possess the same symmetry, the artwork suggests a new geometrical dynamic formation model: permutations of the 5D space cell (epitahedron E+) in the framework of an icosahedron according to Group theory. Hence, it works on the assumption of a higher dimensional spatial structure as a formation generator.

Very Severe Cyclonic Storm Luban, east-northeast of Socotra on 10 October 2018. Peak intensitywinds 140 km/h [85 mph]. VIIRS image captured by NOAA's NOAA-20 satellite, retrieved from: https://en.wiki-pedia. org/wiki/Cyclone_ Luban#/media/ File: Luban_2018-10- 10_0926Z.jpg, [05-08- 2019]

Very Severe Cyclonic Storm Titli, October 8 – October 12, Peak intensity 150 km/h [90 mph], approaching.
Andhra Pradesh and Odisha on 10 October 2018, the disaster entered the Bay of Bengal & killed at least 77 people in Odisha [Image Source: VIIRS image captured by NOAA's NOAA-20 satellite - NOAA View
Global Data Explorer, retrieved from https://e n.wikipedia. o r g /wiki/2018_ North_Indian_Ocean_cyclone_season#/media/ File:Titli_2018-10-10_0745Z.jpg]

Images on the next pages:
GAIA 5.0,
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Stills from virtual reality:
All images on the next pages are created by Leyla Kern at the HLRS by programming new modules for reading netCDF data sets for the use of COVISE/openCOVER data visualization.
Images generated from ECMWF data with COVISE visualization program.
COVISE /openCOVER image with depicted parameters:
- cc [Cloud coverage], as white clouds
- q [Humidity], on the surface in color

GAIA 5.0,
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Installation view
Photo Riccardo Pareggiani

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Yiwen Liu, Zhuang Wang, Se Wang, Hao Fang und Degao Wang, *Soot Nanoparticles Could Partake in Nucleation of Biogenic Particles in the Atmosphere: Using Fullerene as a Model Compound*, Atmosphere 7(3), 2016, pp. 45.

Frank Raes, Rita Van Dingenen, Elisabetta Vignati, Julian Wilson, Jean-Philippe Putaud, John H. Seinfeld, Peter Adams, *Formation and cycling of aerosols in the global troposphere*, “Atmospheric Environment”, 34, 2000, pp. 4215-4240, JRC21037.

Paul Virilio, *Lost Dimensio*n, New York: semiotexte, 1991 (orig. L‘espace critique, Paris, 1984).

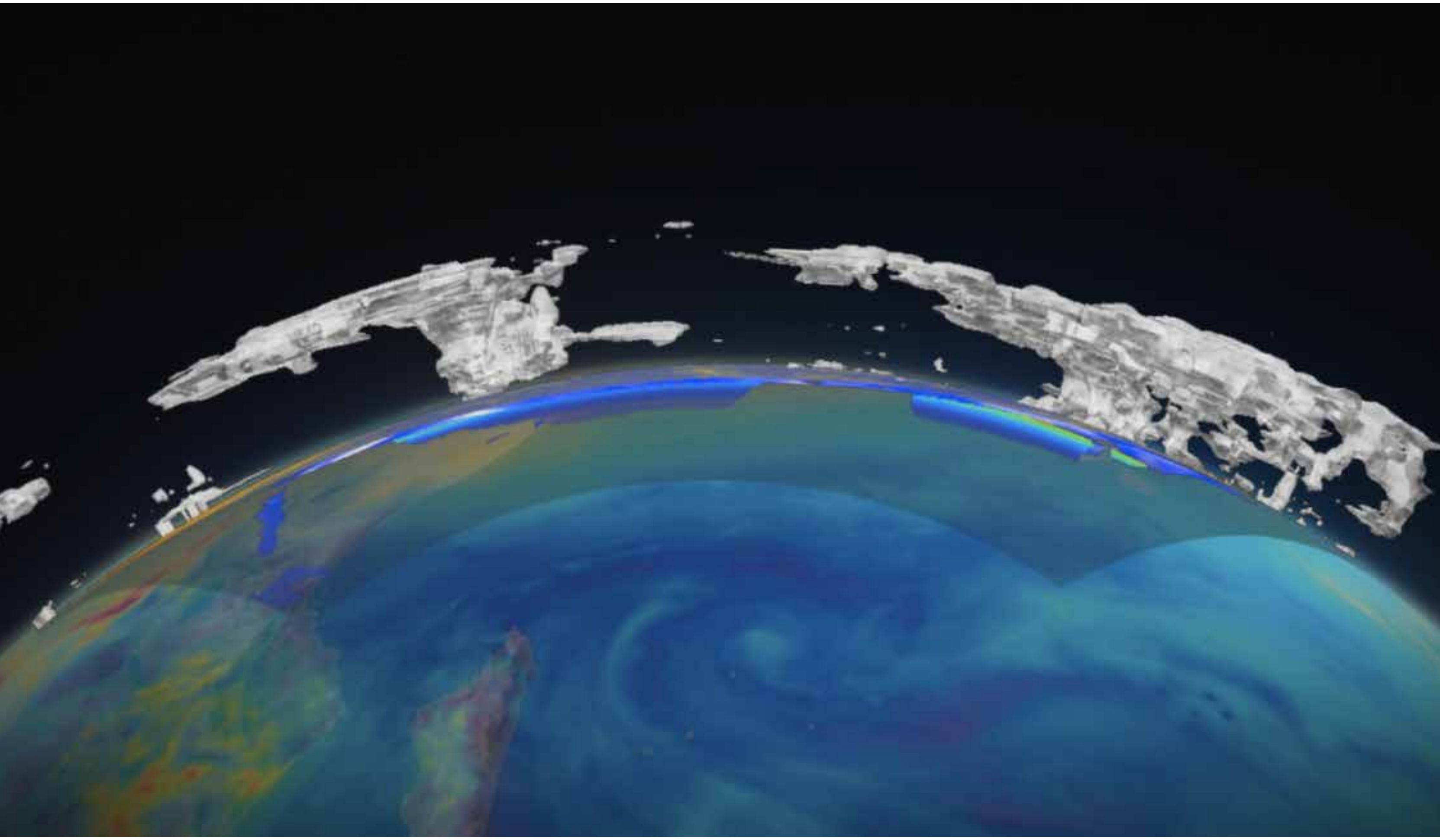
Link to film:

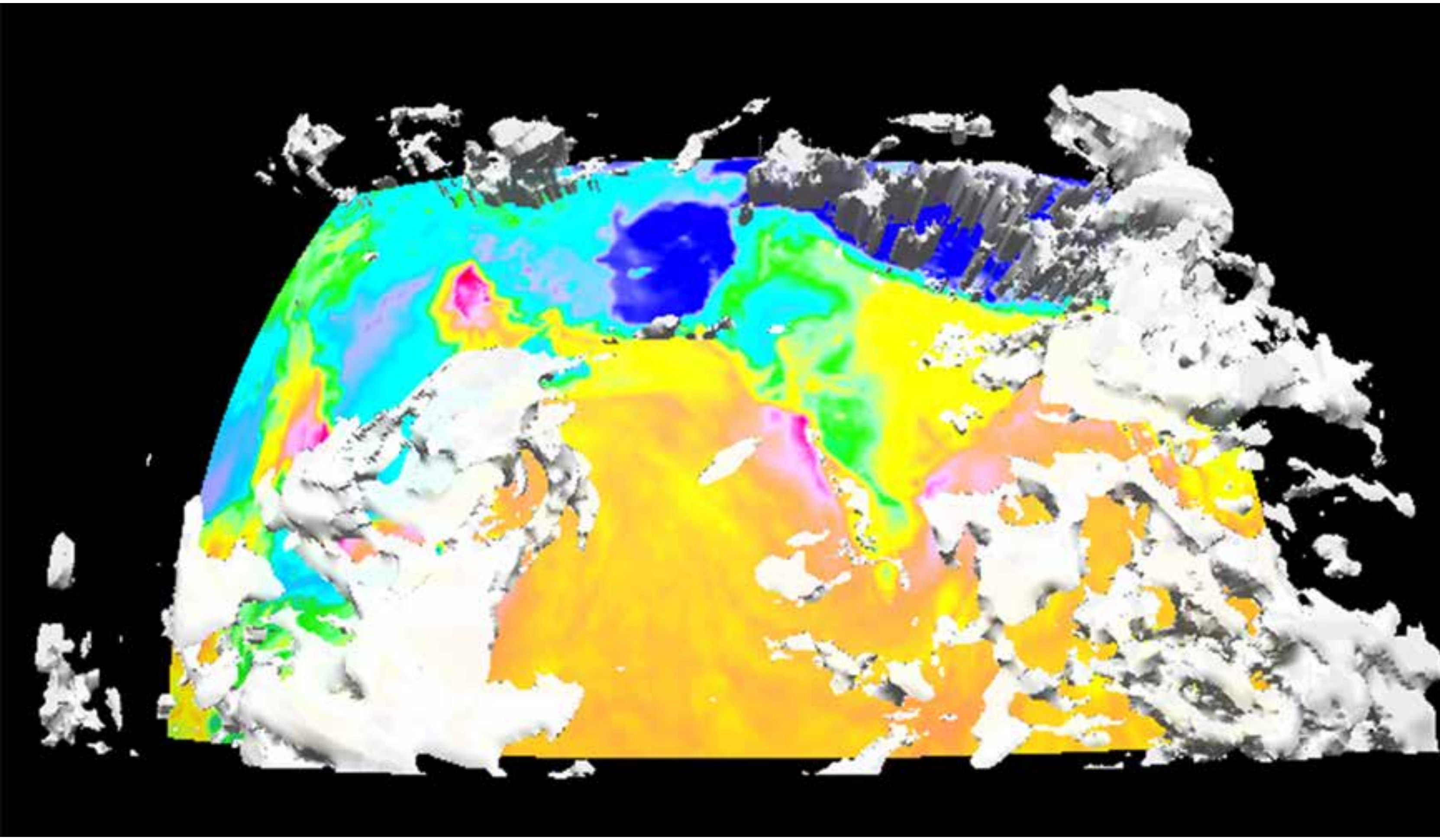
vimeo.com/397963836 Login: ENJOY72

Film *Epitadodecahedron* , IMAGINARY, ICM Seoul (KR) 2014: http://www.imaginary.org/film/the-epita-dodecahedron-visualizing-poincares-dodecahedral-space

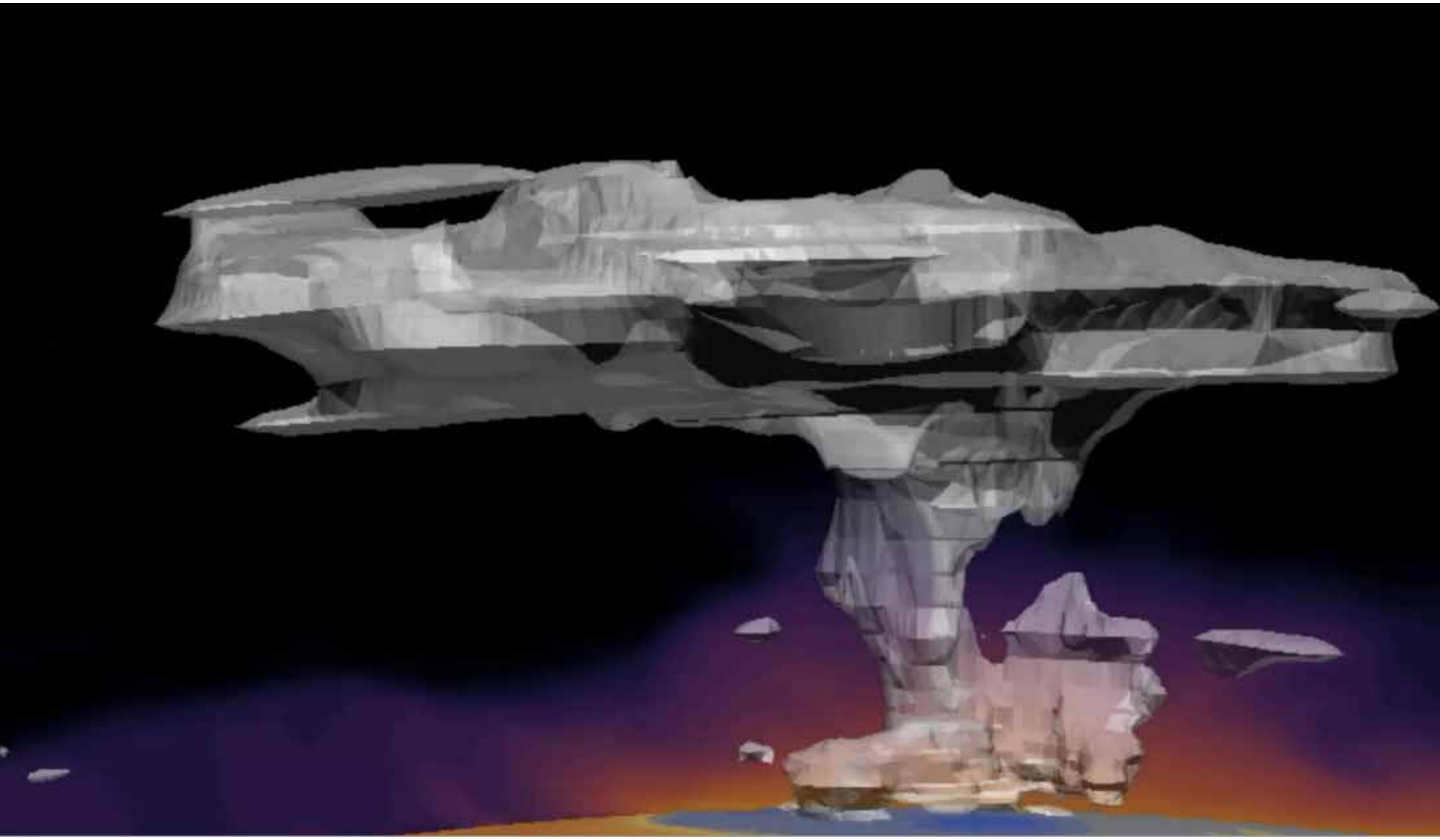
Notes

1 A chiral object is an object of which the mirrored image is different from the original. The most known chiral object is the hand [the word is derived from the Greek word for hand].

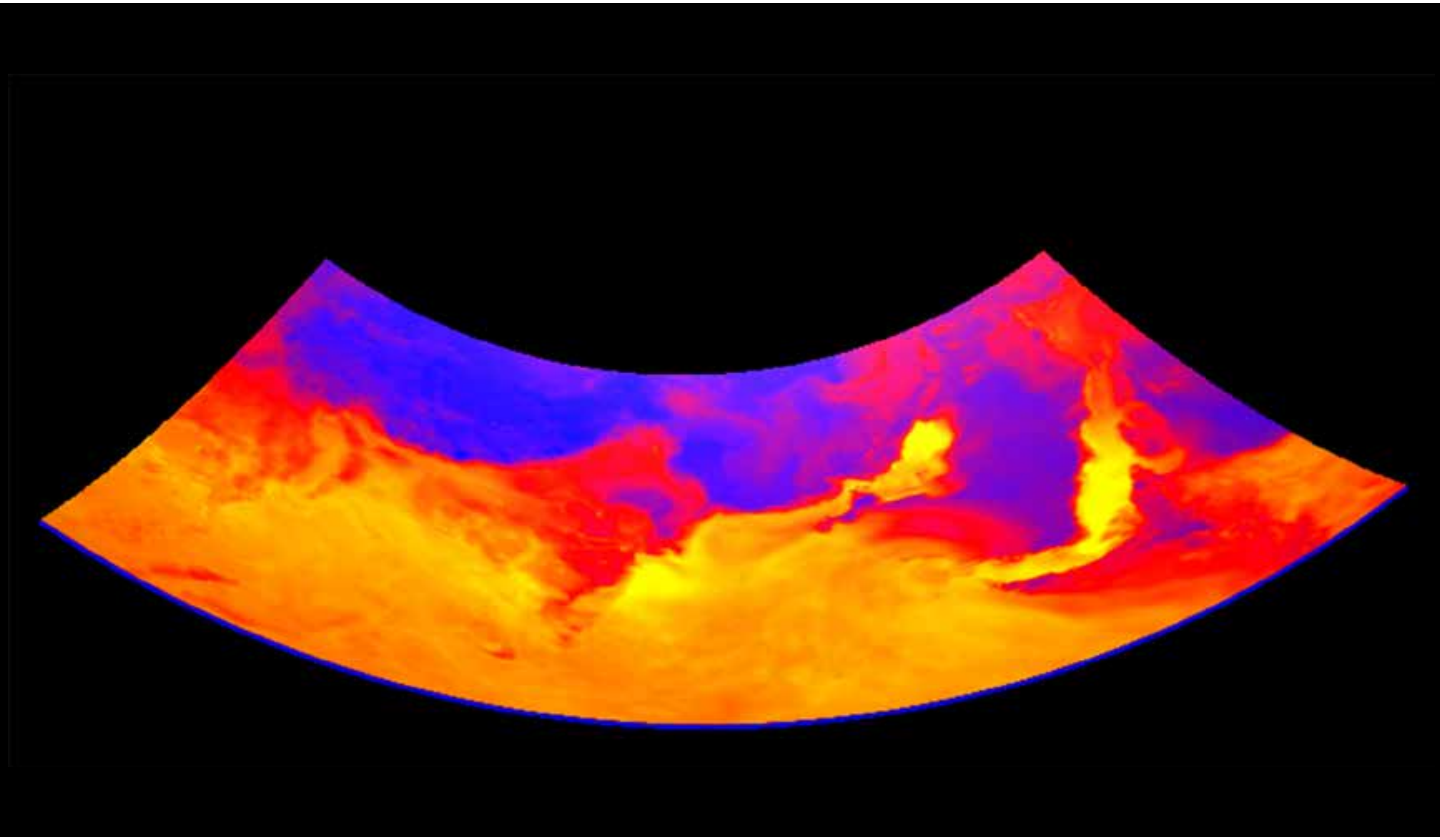




File: era5_pressure_LUBAN_TITLI_20181013.nc
Depicted parameters:
 - cc [Cloud coverage], as white clouds
 - q [Humidity], on the surface in colour



File: era5_pressure_LUBAN_TITLI_20181014.nc
Depicted parameter:
 - cc [Cloud coverage], as white clouds



File: era5_pressure_LUBAN_TITLI_20181014.nc
Depicted parameters:
- h [Humidity], on the surface in colour

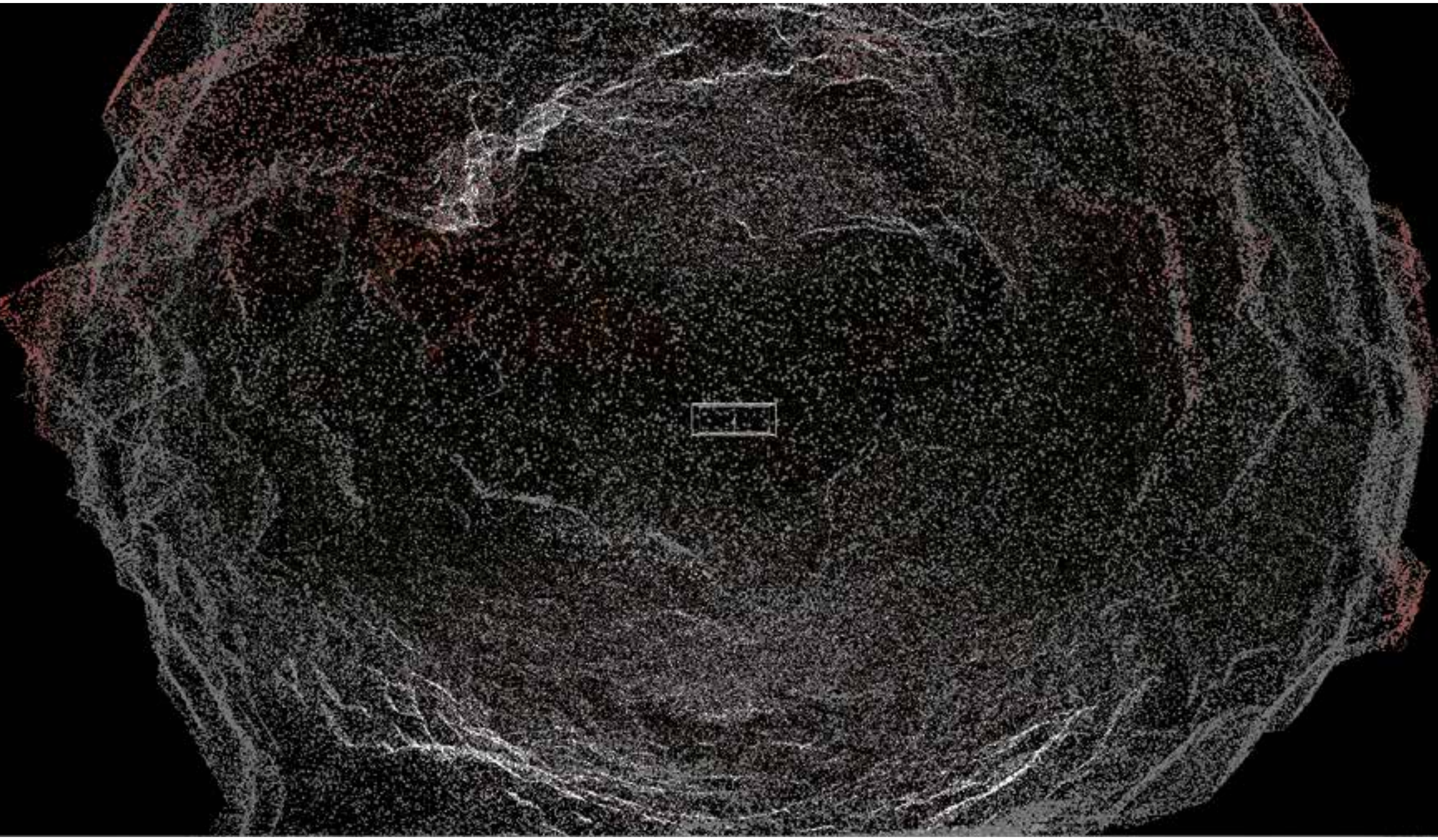
Resonance Space[s]

Artist
Alexander Peterhaensel

Scientists
Daniel Tirelli
Jutta Thielen-del Pozo
Thomas Petroliagkis

Collaborators
Julian Netzer
Christopher Höhn

Resonance Space[s],
SciArt Datami project, 2019
Sculpture Immersive audiovisual experience - VR
- Interactive Big Data
15′-infinite duration



Resonance Space[s],
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Point cloud rendering
Still Alexander Peterhaensel Archive

Resonance Space[s]

Alexander Peterhaensel

Nature will not grant us any special treatment just because we consider ourselves the 'pride of creation.' [...] I'm afraid nature is not vain enough to cling to human kind just as a mirror, in which it can see its own beauty.[1]
Prof. Dr. Hans-Peter Dürr (Physicist)

Big Data and the Human Condition in the Digital Age

We argue that the development and widespread use of ICTs[2] *are having a radical impact on the human condition. More specifically, we believe that ICTs are not mere tools but rather environmental forces that are increasingly affecting:*
1. our self-conception (who we are);
2. our mutual interactions (how we socialise);
3. our conception of reality (our metaphysics); and
4. our interactions with reality (our agency).
Luciano Floridi et al, Onlife Manifesto[3]

Following the invitation of the JRC to attend the Sci-Art Resonances III Summer School in 2018, I was given the opportunity to connect with some of the brightest minds in science, art and policy making in Europe. The curatorial team of the Resonances Festival had observed a lack of awareness in the greater public towards the so-called "digital transformation". In response they not only instigated a cross-disciplinary dialogue between participating artists and scientists, but also encouraged us to deeper contemplation on how to address and tackle the challenges of the digital age.

The aforementioned quote from the *Onlife Manifesto*, which was developed in an initiative of the European Commission's Directorate General Connect, argues that ICTs[4] are to be understood on a grander scale. Floridi et al. compare them to environmental forces, which not only transcend the concept of being applicable tools, but also gain their own agency to influence our very behaviour. The implications are so vast in scale and complexity that they will most likely change not solely the behaviours of individual human beings, but also our behaviour as a species. Floridi et al propose four vectors to categorise the impact of these environmental forces: 1) Our understanding of who we are, 2) the way we socialise, 3) our understanding of reality, and 4) our agency, meaning the way in which we interact with, what we perceive as, reality.

One of the leading questions under which we were supposed to develop ideas was whether we need to be afraid of Big Data and its implications. In the light of the observable hubris and hype surrounding Big Data, I would propose to ask: "Do we really need Big Data (in its hyped form)? And what do we actually need it for?" In other words, is amassing more and more data going to make us any more human?

In order to grasp the impact of Big Data on our metaphysics, I would propose to understand the Big Data phenomenon as a cultural technique of seeing, a cultural technique for imaging. A looking glass, through which we can render[5] a perspective on reality. We should keep in mind though, that the rendering of a perspective on a data set is always just a calculation inside a mathematical model of reality. If we understand Big Data as this CGI-driven looking glass, I find it most interesting to pose the question: "Does the lens of Big Data actually help us to develop a better understanding of the world, of ourselves, of the universe?"

In my artistic approach, I was inspired to address the four vectors proposed by the *Onlife-Manifesto*. I wanted to create an aesthetic experience, which would ideally lure the spectator into developing an intuitive feeling for the possible shifts in these four impact vectors, in regards to how we see ourselves as humans. Furthermore, I was very curious to explore Big Data sets at the JRC and get into a discourse with the scientists. I was intrigued, whether I would find some partners who would be interested to create an artefact together, which would ideally mirror the human condition in the reflection of Big Data.

Interdisciplinary Discourse [as answer to the challenges of the Digital Age]

All things, at least those we know, contain number; for it is evident that nothing whatever can either be thought or known, without number.[6]
According to Pythagoras

The Tao which can be expressed in words is not the eternal Tao.
According to Laozi

The digital, or better yet, algorithmic era leads to an immense increase in complexity, which creeps into every aspect of our lives. The observable blurring of discipline boundaries, which goes along with said algorithmic revolution, is increasingly creating problems that are magnitudes more complex than anything we have been confronted with as a species so far. Interdisciplinary thinking and problem-solving seem to be our best bet to tackle the challenges of an infinitely interwoven, globalised world.

The collaboration of scientists with artists holds a lot of potential, since both disciplines are creative per se. Both are making something visible, which has been obscured to us before – either knowledge or an idea or a question. Also, if taken seriously, the scientific research process, just as the artistic, is open-ended. That means: if a scientist or an artist are setting out to find something new, they generally don't know the result of what they are going to find.

Already during the Resonances III Summer School of June 2018, and in the following months, I was fortunate enough to share inspiring, open-minded dialogues with several scientists at the JRC. In these conversations and discussions, they generously shared their knowledge and wisdom, and, ultimately, spawned more ideas and thoughts, than it was even possible to process in the course of one year.

As intended by the curatorial concept of the Resonances III Festival, I was able to establish a working relationship with several scientists of the JRC, based on an open-minded and open-ended dialogue, addressing pressing societal questions and concerns. It led us to an interdisciplinary collaboration in its truest sense: a dialogue, in which all involved parties took the time to fully appreciate the different thought perspective of the other parties, and, as a result, generated new perspectives for everybody involved. Ultimately, it led us to create something none of us could have ever imagined. In retrospect, I would describe this high-potential environment, created by the SciArt program at the JRC, as a kind of resonance field between Pythagoras and Laozi, who opened up this chapter.

Me oscillating in this resonance field with Jutta Thielen-del Pozo, Daniel Tirelli and Thomas Petroliagkis, resulted in a scientific-artistic artefact, which discusses maybe the most pressing issue of our times: climate change and our role in it as humans.

Daniel's Hypothesis

Ironically, what ultimately led to the conception and spawning of the piece was not ticking off the names from the list of scientists I had wanted to talk to, discussing Big Data sets, as I had anticipated in my mind. But much rather: the idea for the piece was revealed by total coincidence during an intense conversation with Daniel Tirelli – at a time when none of us expected this. Daniel, a geophysicist (working at the *European Laboratory for Structural Assessment* or ELSA), took the time to describe his streams of research, and, in great detail, his underlying thought processes. In several more conversations, he managed to enlighten me about his findings on multi-harmonic oscillation patterns in bridge cables.[8]

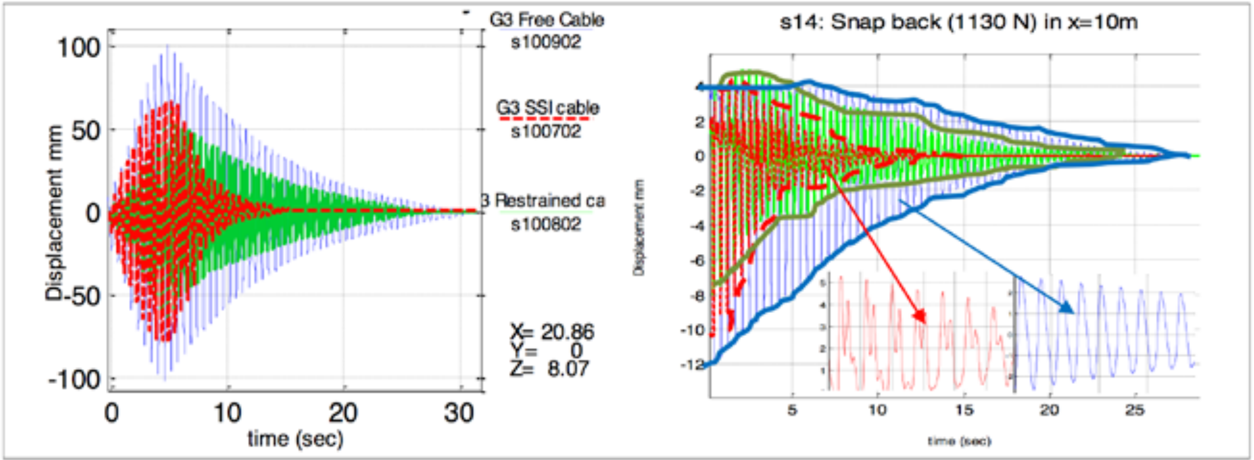
What fascinated me from the beginning was the fact that Daniel used a language full of metaphors, often relating to musical analogies, as a reference for explaining complex models. He explained to me the chaotic behaviour in bridge cables, and how the cables become more robust and durable once they start resonating in multi-harmonics – similar to guitar strings when played as flageolet. By doing so, the energy is redistributed in the cables and their robustness increases substantially. What ultimately sparked my inspiration for the art piece was Daniel's hypothesis: He proposed an analogy between the multi-harmonic oscillation of the cables and the multi-harmonic oscillation of the climate in our geosphere.

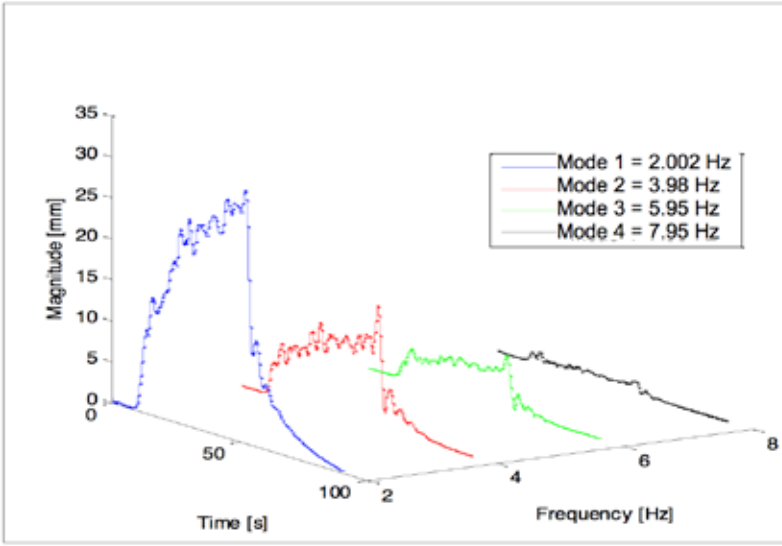
During the discussion of his sketch, Daniel proposed what I found to be an incredibly poetic metaphor: the global climate resonates multi-harmonically as a reaction to the behaviour of our species. It does so by redistributing the energy, which we are injecting into the geosphere (by our energy consumption, by burning fossil fuels), into multi-harmonic oscillations, i.e. of the temperature curve, in order not to collapse. His hypothesis offered a beautiful explanation for the increasing weather extremes we are perceiving. This image of the resonating geosphere stuck in my head.

After this conversation, both of us started researching for evidence of Daniel's hypothesis. We found it in James Hansen's and Makiko Sato's 2016 paper "*Regional climate change and national responsibilities*"[9].

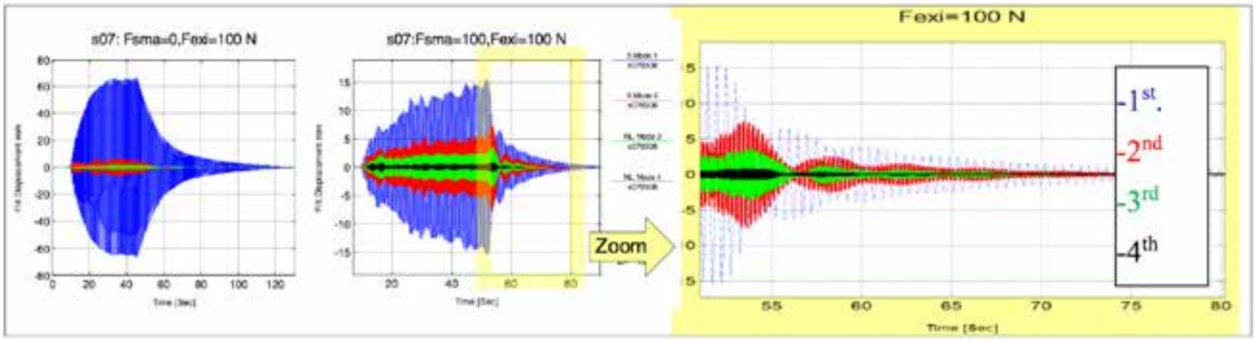
In their paper, Hansen and Sato show that "regional climate change is emerging above the noise of natural variability, especially in the summer at middle latitudes and year- round at low latitudes". Most revealing are their data curves, which show the frequency of temperature anomalies in the last four decades. Upon studying the paper together, Daniel pointed out that Hansen's findings about the temperature oscillations were in perfect correlation with his research on the non-linear cable behaviour.

The chaotic temperature oscillation can be interpreted as an indicator of the fact that the energy levels contained in our geosphere must have risen over a certain threshold. In order to stay within system critical minima and maxima, our climate seems to be redistributing the energy by folding it into multi-harmonics in temperature. This means, that in order to maintain overall stability (not exceed certain temper-





Tirelli, Anthoine [2014],
A new Therapy for cable
vibrations: the state
switched inducer



atures), micro climates have been increasingly deviating from a smooth curve over the course of the year.

At this point, I was convinced that I wanted to translate Daniel's poetic metaphor into an aesthetic experience. I wanted to translate his scientific hypothesis into a spatial experience – ideally, I wanted to create a dialog space that would allow for and initiate a solution-oriented discussion on the problem of human-induced climate change amongst scientists, general public, and policy makers.

I had my idea, I had found a partner in crime and we had a thrilling narrative. All I needed now was the suitable raw material in order to sculpt the spatial experience I had in mind. I wanted to narrate our story through a Big Data set of climate data.

Sculpting with Big Data

I turned to meteorologist Jutta Thielen-del Pozo for scientific and conceptual advice, and also to gather an understanding of available Big Data sets on meteorological data at the JRC. During several dialogues and discussions about Daniel's hypothesis, Jutta introduced me to various meteorological data models and helped me in finding a suitable one in relation to Daniel's hypothesis. Jutta, who was intrigued by the proposed data narrative, generally agreed with Daniel's hypothesis, but pointed out details that needed some refinement and clarification. The dialogue between Jutta and Daniel about details of the hypothesis is still ongoing. Its results will be included in the collaborative paper we are preparing on this project.

After helping me with the outline of a suitable meteorological Big Data set, Jutta kindly pointed me in the direction of meteorologist Thomas Petroliagkis, to help with the final data set assembly. Throughout the entire development process of the project, Jutta always had an open ear, always found time for discussions – even in the most hectic times.

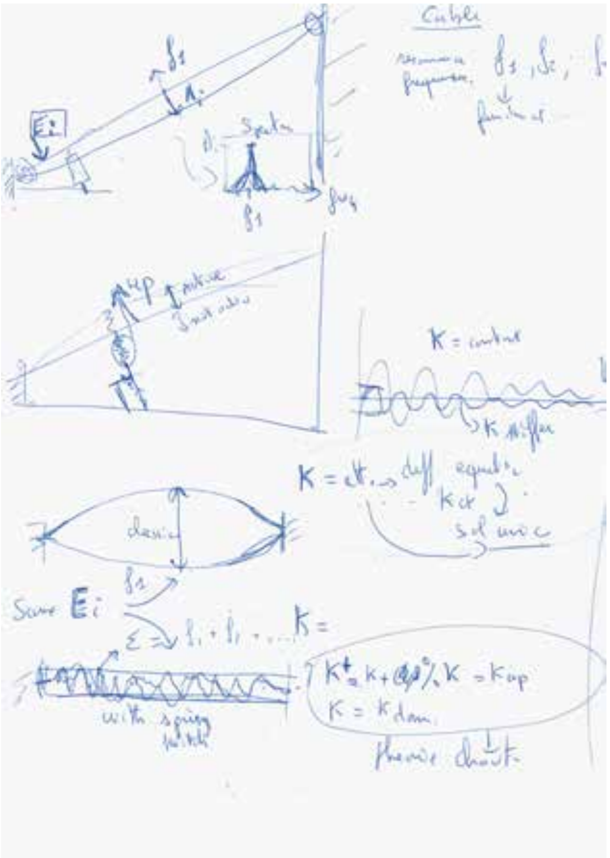
Thomas was also a pure pleasure to work with. He went out of his way to make sure we got the right Big Data set. He too was intrigued by Daniel's hypothesis, and we went into a sustained dialogue about which aspect of the global meteorological data sets available at the JRC would be the most suitable for our purposes. Being a huge fan of meteorological visualisation models, I wanted to preserve the serenely beautiful flow of air streams, clouds and temperatures, yet I also wanted to find a way to communicate the increasing unbalance and chaos in our climate – what Daniel had called the chaotic multi-harmonic oscillation.

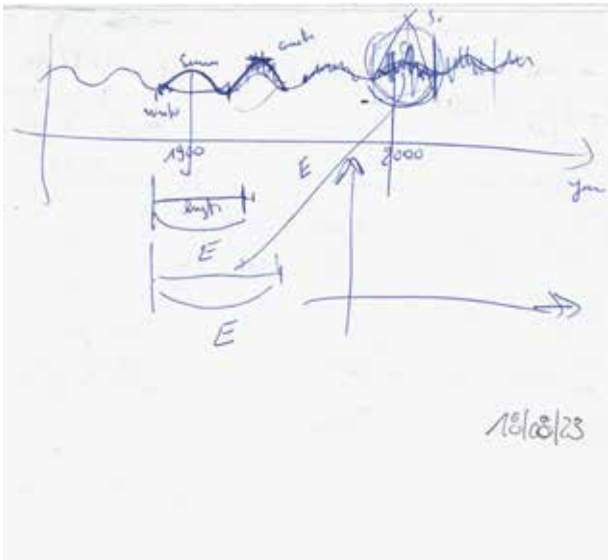
Over the course of several months, Thomas and I kept working on finding suitable data sets. There were several challenges to overcome. First of all, we had to find a way of handling the huge amounts of data. My idea was to look at various meteorological parameters on a global scale, which meant we were looking at global data sets.

Then, my team and I had to develop a pipeline for digesting and interpreting these data. Building on our previous research[10] , we developed a real-time solution for projecting the meteorological Big Data sets in VR, so that we could visually understand the movement and possible oscillation of values. In addition, we wanted to evaluate the aesthetic qualities of these data in order to understand the potential for the Big Data narration I had in mind. This was a wonderful and joyful process. We were basically bathing and showering in Big Data, mesmerized by the data points whirling around us. We felt like little kids, exploring the possibilities for visualising these data clouds.

Ultimately, we ended up with an assembled Big Data set of the entire globe, depicting the temperature for each day of the year 2018, from the surface of the earth all the way up to the mesosphere at 64 km altitude, which resulted in a total of 2.5 billion[11] data points.

Even though this number might sound intimidating, it shall not obscure our purpose. Truly awe-inspiring are not the competitive exhibitions of data points. Truly awe-inspiring are the moments when we recognise something in the data points – when we understand something through the data points. There were several moments when we were awe-struck during the prototyping process, gazing at the beauty of winds and seasons whirling around us.





Resonance Space[s],
Resonances III Datami
Daniel Tirelli,
Sketch during one of our
first conversations
explaining his hypothesis, 2018

We realised that, to even begin to understand a system like the earth's climate in its entirety, to grasp it intuitively, a cultural technique like Big Data seems to be of great help. However, returning to the opening quotes by Pythagoras and Laozi, how can we gage the nature of things within the numerical abstraction? An interesting duality shone up: an analogy between the dualistic logic of the binary world, and the irresolvable oscillating resonance between Pythagoras' reign of the digits and Laozi's realization on the irreconcilableness of the *physis*[12] of things and its very description. As if this duality was constantly oscillating between 0 and 1. The challenge here seemed to be, to focus our gaze within the sheer infinite data – to tune this recognition instrument, in order to discern the *physis* of our climate.

Our Datami: Resonance Space [AR/VR] – An Interactive Big Data Sculpture

Everything flows[13]
According to Heraclitus

Our *opera*[14] for the Resonances III exhibition takes the shape of an interactive Big Data sculpture. The room-scale Augmented-Reality installation attempts to unfold the *physis* of our planet in all its *unconcealedness*[15] in 2.5 billion data points. It invites the spectators to an audio-visual meditation on human-induced climate change. The installation translates a scientific hypothesis into an immersive experience, and hence facilitates an intuitive understanding of our actions as a species and their implications on our geosphere. The work also addresses the four major transformations of the digital age, as outlined in the *Onlife Manifesto*[16], in the following form:

(A) The blurring of the distinction between reality and virtuality

Building on previous works and research by the artist[17], *Resonance Space (AR)* augments the physical exhibition space with a virtual information layer, which is projected around the spectators. A virtual space depicting a Big Data set of the global temperature, is projected as a second skin onto the physical space. This results in a hybrid virtual-analogue texture, which has no physical materiality, yet a very real presence. The augmentation layer mediates the spectators' sensation and therefore completely transforms the perception of the physical space.

(B) The blurring of the distinction between human, machine and nature

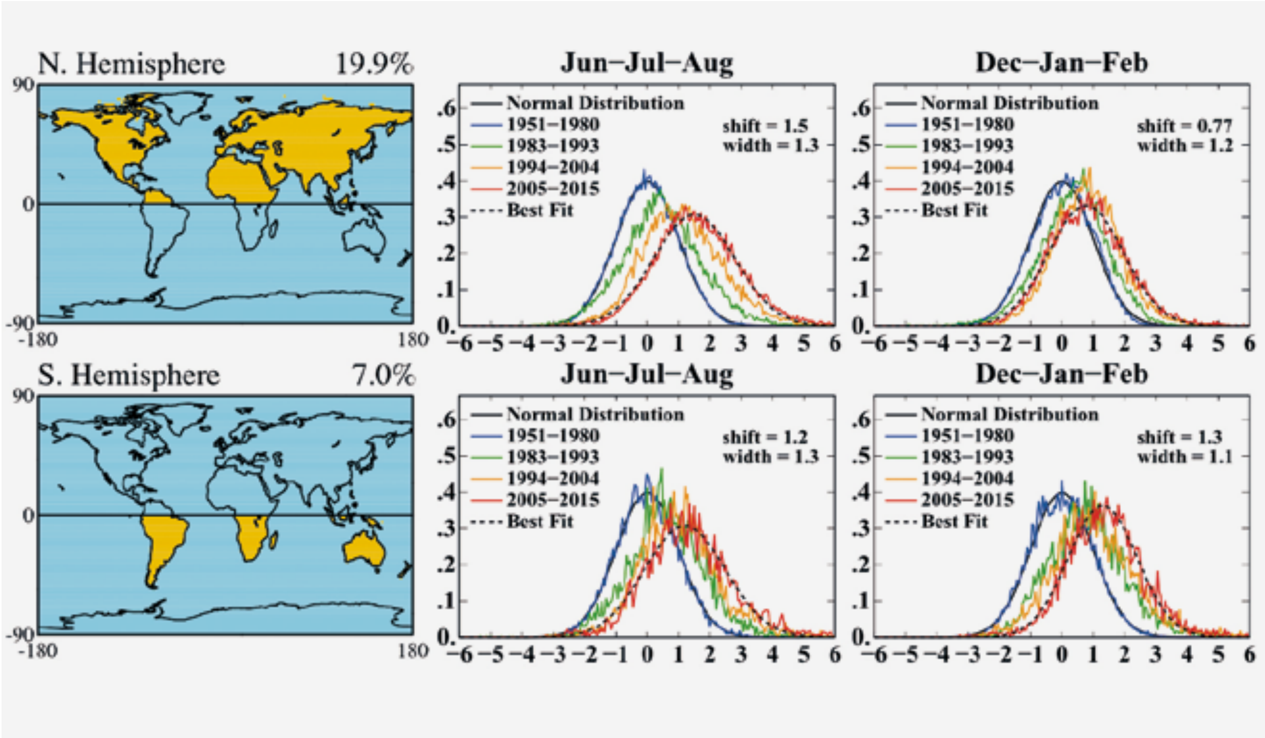
Resonance Space (AR) is a *sensponsive*[18] Big Data sculpture, which realises itself through the multimodal co-authorship of a) the spectator's behaviour, b) the behaviour of the mediating IT-apparatus (responding to the visitors' behaviour), and, c) the behaviour of the geosphere (as depicted by the Big Data set).

(C) The reversal from information scarcity to information abundance

Recognising the potential of Big Data visualisation as a cultural technique, *Resonance Space (AR)* translates a global temperature data set into an aesthetic experience. Being aware that without Big Data, it would be impossible to grasp the world climate in its entirety, we set out to find ways of representing the Big Data set in a form that would allow for an intuitive understanding of the complex flow of chaotic behaviour.

On the one hand, we wanted to allow the spectators to be overwhelmed by the beauty of taking a bath in the data, placing them in the eye of a data hurricane and completely submerging them in a cyclone of data points whirling around them. On the other hand, we also found it very important to find a sweet spot – or a focal point – in the data set, which would allow for a meditative resonance of the spectators with the serene beauty of the complex behaviour these data depict.

(D) The shift from the primacy of stand-alone things, properties, and binary relations, to the primacy of interactions, processes and networks.

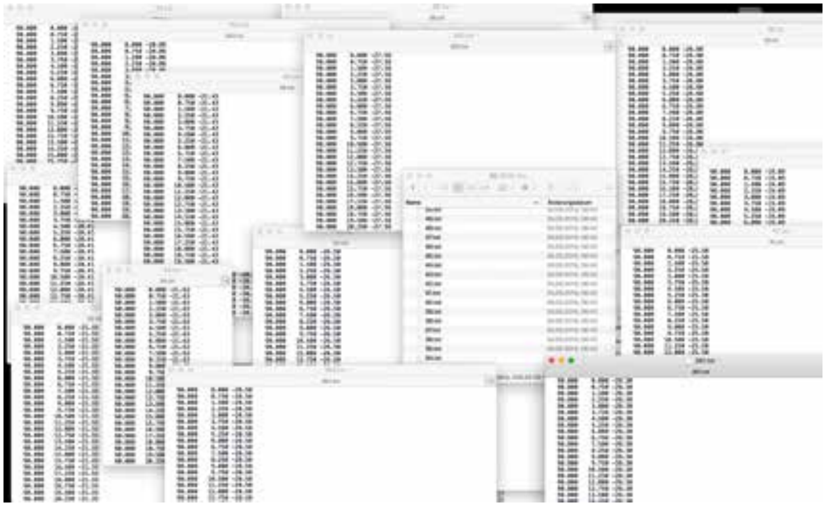


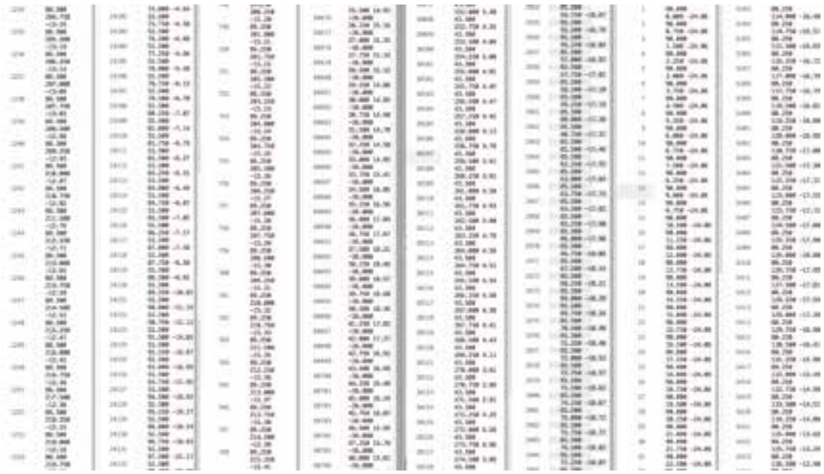
J. Hansen [2016], oscillation of the temperature, curve, Source: James Hansen and Makiko Sato, 2016 Environ. Res. Lett., 11, 034009

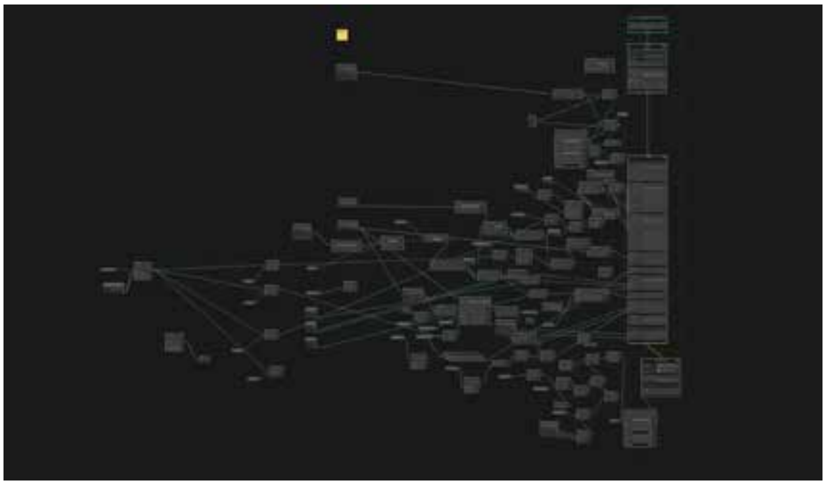
We translated Daniel's scientific hypothesis into an interactional model. The installation resonates aurally and visually according to the spectator's behaviour. This means that the presence of the spectator informs the behaviour of the immersive environment.

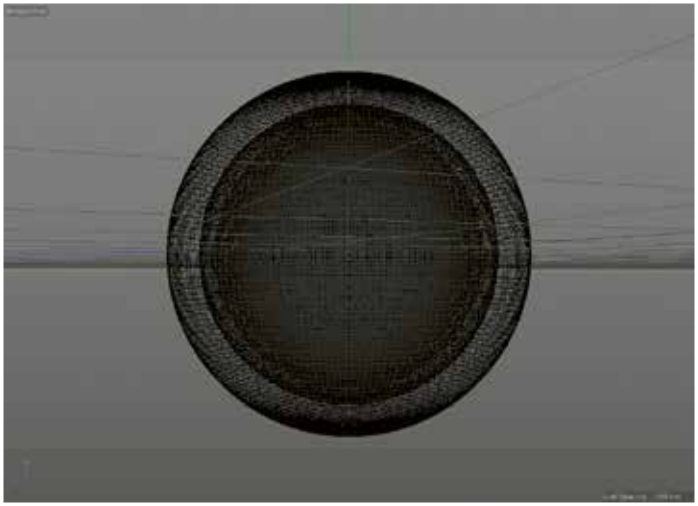
The installation is equipped with several cameras and motion sensors in order to gather an understanding of the activation level of the spectators. The spectators' interactional model. The installation resonates aurally and visually according to the spectator's behaviour. This means that the presence of the spectator informs the behaviour of the immersive environment.

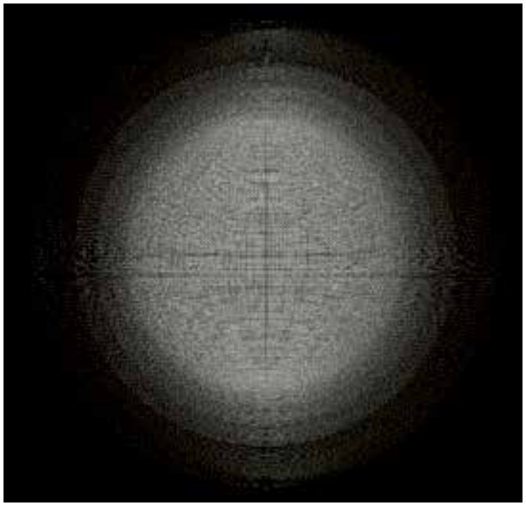
The spectators' behaviour drives the agitation of the environment, or, differently put: the presence of human spectators incites the environment into differently resonating states of excitation. The calmer the spectators, the calmer the environment. If the spectators are more active, the environment will resonate in multi-harmonic oscillation. The implemented interactional model is comprised of a network of actors, who, co-actively, author the current state of the installation. We can also observe an overlapping and blurring of agencies in the authorship of the realised artwork between the human spectator(s), the media-technological apparatus, the scientists and the artist.

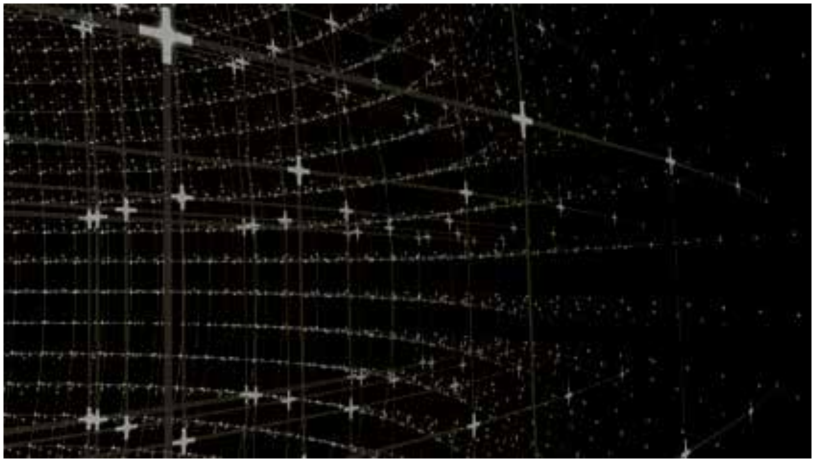












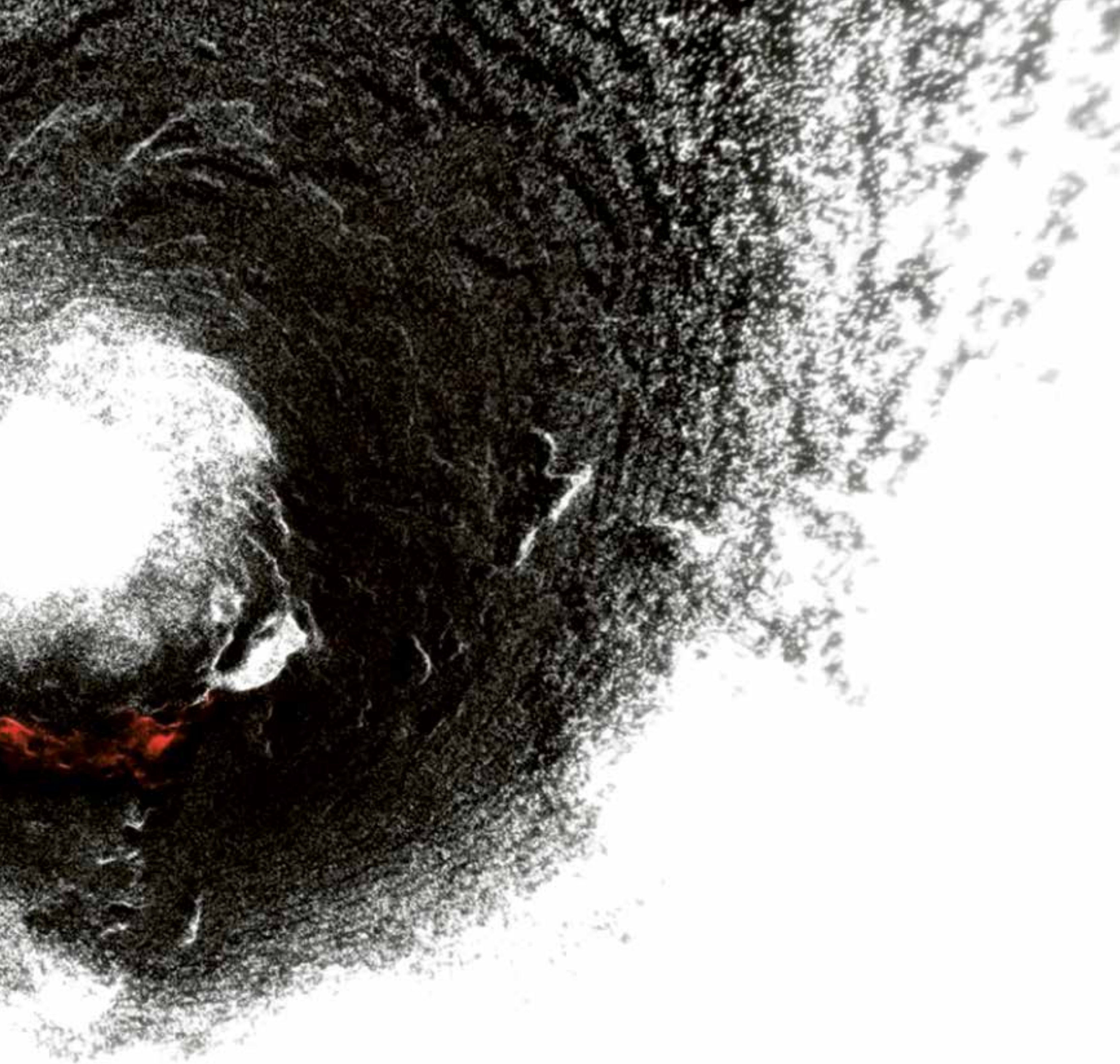
Resonance Space[s],
Resonances III Datami
Artefacts of the Big Data
interpretation process by
Alexander Peterhaensel Archive

Resonance Space[s],
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 – 19 January 2020
Installation view
Photo Riccardo Pareggiani

Notes

1. See H.-P. Dürr in *DER SPIEGEL* 05/1996, „Pflicht zur Mitnatürlichkeit" [„Obligation to Co-Naturalness"], author's translation. Original: "Die Natur wird uns keine Sonderbehandlung gewähren, nur weil wir uns als ‚Krone der Schöpfung' betrachten. […] Ich fürchte aber, die Natur ist nicht eitel genug, um sich an den Menschen als einen Spiegel zu klammern, in dem allein sie ihre eigene Schönheit sehen kann."
2. Information and Communication Technologies
3. Floridi, Luciano [ed.], *The Onlife Manifesto,* 1, Springer, DOI 10.1007/978-3-319-04093-6_1, 2014
4. Information and Communication Technologies
5. "to render" is used in the sense of the mathematical operation of calculating a computer-generated image [CGI]
6. Guthrie, Kenneth Sylvan, *PYTHAGORAS* Source Book and Library, New York: The Platonist Press, page 189, 1919
7. Giles, Lionel; et al., eds., *The Sayings of Lao Tzu, The Wisdom of the East,* New York: E.P. Dutton & Co. 1905
8. Tirelli, Antoine, *A New Therapy for Cable Vibrations: The State Switched Inducer, Presentation at the Symposium on the Dynamics and Aerodynamics of Cables* – SDAC 2014 [proceedings not published], 2014.
9. Hansen, James and Sato, Makiko, [Environ. Res. Lett. 11 034009, 2016.
10. See Peterhaensel, Alexander, "Immersive.Architecture. Generator: Framework for Adaptive Audiovisual Environments", In: *Ayşegül Akçay Kavakoğlu* [ed.], AMPS Proceedings Series 14. Moving Images – Static Spaces. Altinbaş University, Istanbul, Turkey. 12 – 13 April, 2018. pp.169-180, Ayşegül Akçay Kavakoğlu. ISSN 2398-9467.
11. Precisely, the data set contains 2.533.392.000 data points.
12. Ancient Greek "physis": „Physis describes the process of genesis, growing, blossoming rising, as well as the essence and the quality of a thing", Author's translation. Original: "Physis bezeichnet sowohl den Prozeß des Werdens, Wachsens, Blühens oder Aufgehens als auch die Beschaffenheit oder das Wesen eines Dinges.", See Chris Höhn, *Was ist Natur? Klassische Texte zur Naturphilosophie,* Herausgegeben von Gregor Schiemann, Deutscher Taschenbuch Verlag, 1996, München, S. 12, 2019.
13. Chitwood, Ava, *Death by Philosophy, [The Biographical Tradition in the Life and Death of the Archaic Philosophers],* The University of Michigan Press, page 67, 2004.
14. See definition of opera in the DATAMI manifesto at the beginning of this book.
15. See the concept of Aletheia [Ancient Greek: ἀλήθεια], wich describes truth or disclosure in philosophy. The literal meaning of the word ἀ–λήθεια is "the state of not being hidden; the state of being evident."It is commonly translated as "unclosedness" or "unconcealedness" in English. See Wikipedia at https://en.wikipedia.org/wiki/Aletheia.
16 Floridi, Luciano [ed.], *The Onlife Manifesto,* 1, Springer, DOI 10.1007/978-3-319-04093-6_1, 2015.
17. See Peterhaensel, Alexander, "Immersive.Architecture. Generator: Framework for Adaptive Audiovisual Environments", In: *Ayşegül Akçay Kavakoğlu* [ed.], AMPS Proceedings Series 14. Moving Images – Static Spaces. Altinbaş University, Istanbul, Turkey. 12 – 13 April. pp.169-180, Ayşegül Akçay Kavakoğlu. ISSN 2398-9467, 2018.
18. Sensponsivity is a term coined by Oungrinis and Liapis, describing the shift from mere reactive behavior of interactive systems to an "Ambient Intelligence", which would "imbue space with cognitive skills and provide it with a sense of why, how and
when to act", See: Oungrinis, Konstantinos-Alketas and Liapis, Marianthi, "Spatial Elements Imbued with Cognition: A possible step toward the 'Architecture Machine'", in *International Journal of Architectural Computing* 4[12], pp. 419-438, 2014.

Resonance Space[s],
Resonances III Datami
Big Data Sculpture
VR screen capture,
Alexander Peterhaensel Archive



To Breathe

Artist
Siobhan McDonald

Scientists
Francesco Mugnai
Jean-Philippe Putaud

Collaborator
Tullio Ricci, National Institute of Geophysics and Volcanology

To Breathe,
SciArt Datami project, 2019
Mixed Media: Glass prism, volcanic ash, air particles, 24-carat gold, solid silver, smoke, plinth, projector

To Breathe,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Installation view
Photo Siobhan McDonald

To Breathe Datami - SciArt Project

Siobhan McDonald

Man was created of the Earth, and lives by virtue of the air; for there is in the air a secret food of life…whose invisible congealed spirit is better than the whole earth.
Michael Sendivogius (1566-1636)

This project employs the geological materials that lie beneath the Earth's surface in ash, rocks and rare earth minerals to explore the notion of breath between Humans and Nature. I am investigating the sensitivity of volcanic sites as a barometer for our own vulnerability and a reminder of how indelibly we are connected with nature and its workings. The idea emerged from an open-ended process of exploration and experiments with scientists at the JRC and Trinity College Dublin, to explore the notion of Breathing and Air across Europe.

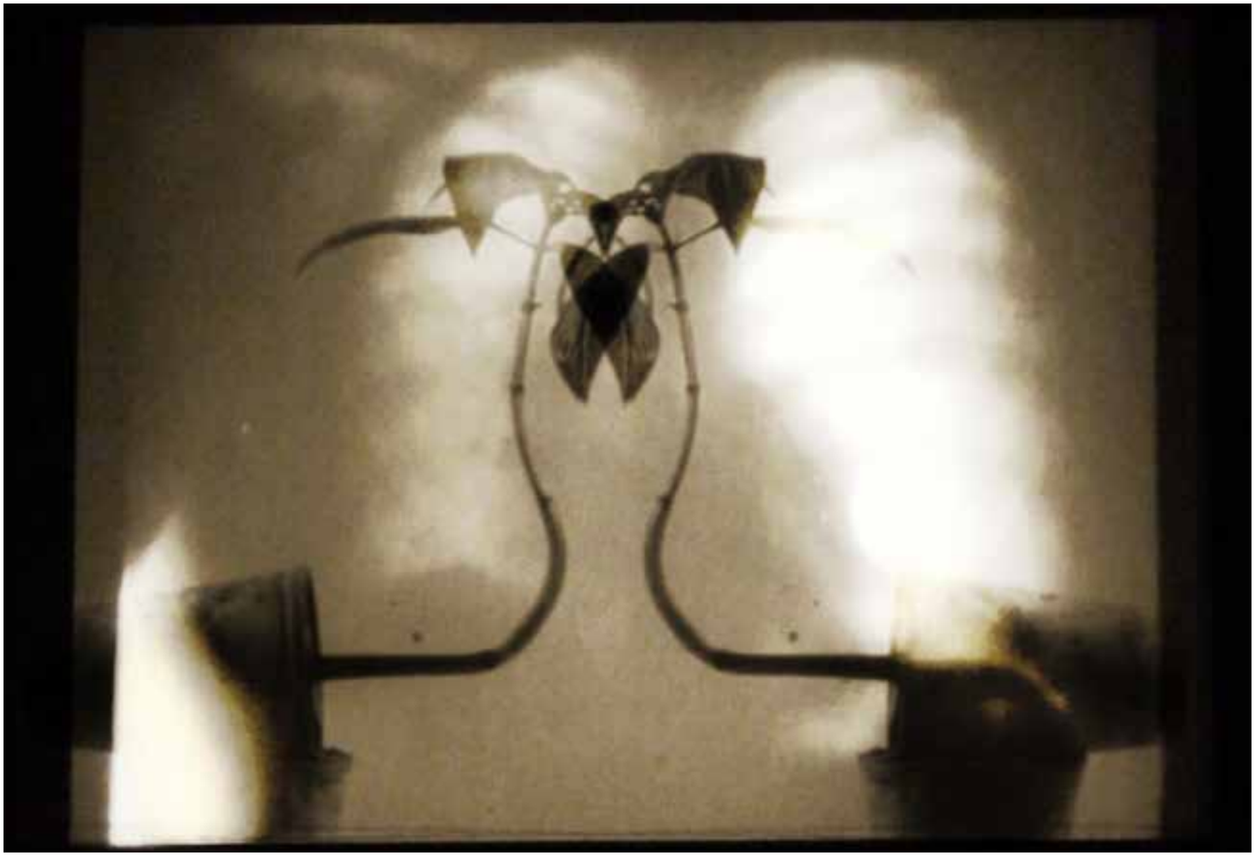
For more than two years, I have developed a line of enquiry about our troubled relationship with nature and pollution. A recent discovery that volcanic ash has the ability to reduce carbon emissions is fuelling a series of enquiries into the symbiosis between man and environment in this ecological crisis. For example, Mount Etna's ash holds a special promise; not only because it is in such abundant supply, but also because it is available in loose particles rather than solid rock.

Connected to Breathe is an installation about the importance of air and the co-existence between the lungs of the earth, humans and plants. It explores a selection of major European volcanoes and points to the cycle of the earth, breathing within the carbon cycle, and the well-being of our ecosystems in this time of climate emergency. The installation explores air pollution as one of the many catastrophes of man's impact on nature. I have chosen to situate the first enquiry on Eyjafjallajökull, the largest glacier and volcano in Europe, as a microcosm representing the larger global Ecosystem, as we enter this phase of human-induced climate change. Since 2010, I have visited this highly eruptive part of Iceland to film the tension and perceived underground silence before an explosion.

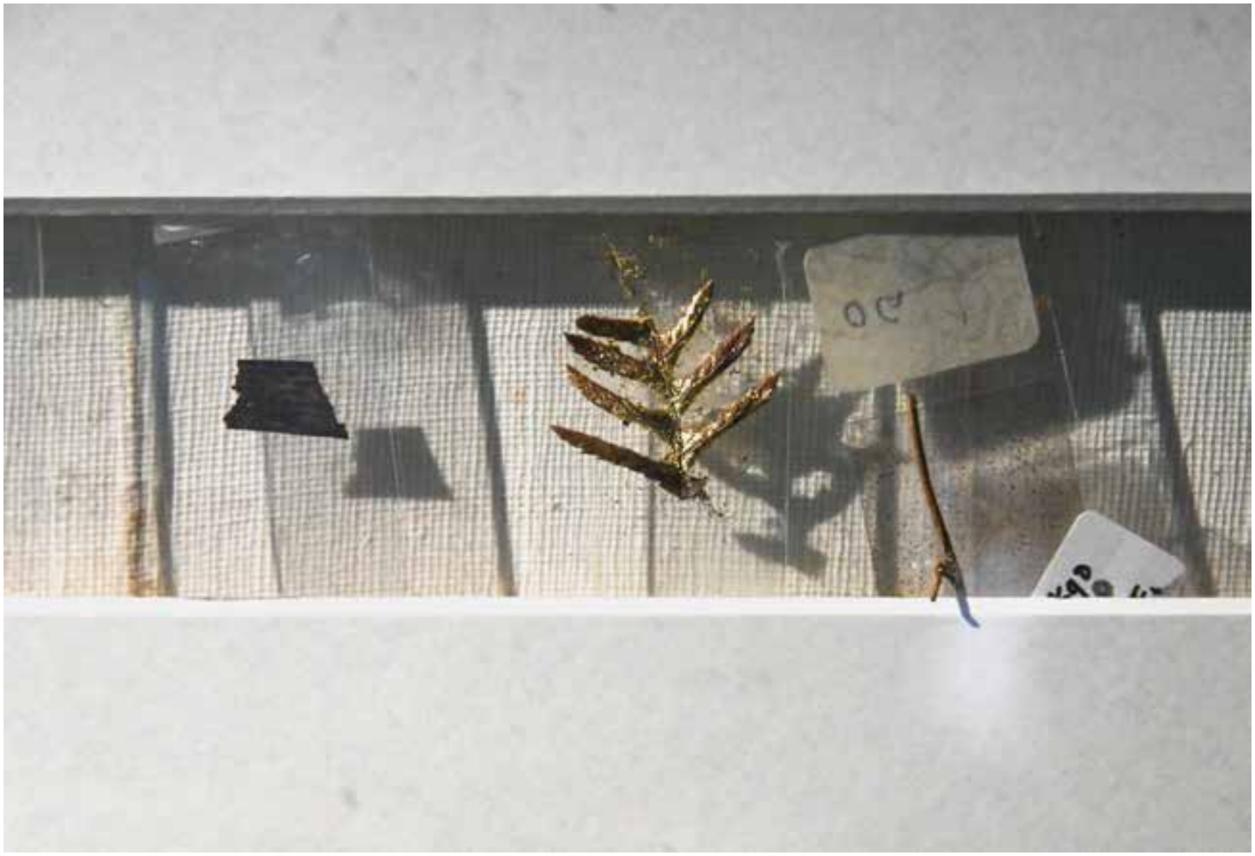
Together with JRC scientists, the project expands into a wider inquiry of air and the role of major European volcanoes such as Etna, Stromboli, Campi Flegrei and Vesuvius, to look at evolution and health through the prism of air. Together with the gracious help from Francesco Mugnai and Professor Tullio Ricci, ash is collected from every site, which I grind into a pigment as source material. Various shades of browns and blacks reflect the specific constitution of the ash. Hence, the raw materials for the pieces embody the primal matter that can help to reduce atmospheric CO2.

As the universe evolves, it creates new dusts for its various eras. At the beginning, the dust of the universe was most likely high packed radiation. This soon decayed into a hot, compressed soup of quarks, which in turn condensed into the ordinary nuclei and matter of our present universe. Eventually all the matter is likely to decay, and the only dusts larger than an electron will be black holes more massive than our sun. But even the black holes decay, and even if the universe lasts long enough the ultimate dust will be greatly diluted cold radiation in a vast vacuum.
Agnes Denes, The Book of Dust, The Beginning and the End of Time and Thereafter, 1989.

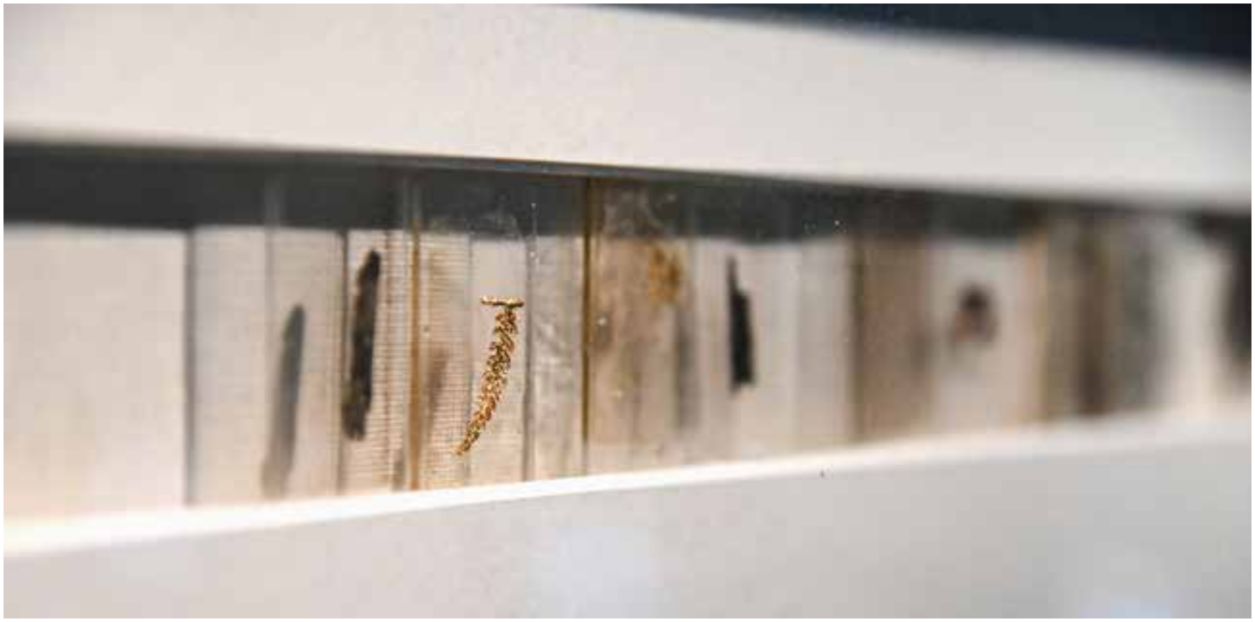
Breathe is a film that weaves together narratives of studies in human breath, medicine and plant remedies from Trinity College Dublin and the *Deutsches Hygiene-Museum*'s archives to explore the idea of coexistence in a world moved by invisible networks (the work was graciously supported by Deutsche Hygiene-Museum Dresden, for the exhibition *Of People and Plants*).



Siobhan Mc Donald,
Still of *Breathe*,
Stereo sound, duration 3′35″,
incorporating plant, tree and human
breath recording 2018-2019
David Stalling, Christopher Ash [film editor]
Graciously supported by the Deutsches Hygiene-Museum
Dresden, for the exhibition "Of People and Plants"



Siobhan Mc Donald,
Herbarium of Breath,
Mixed Media: Volcanic ash, air
particles from over Europe, silver,
earth materials, ancient plant fossils,
gilded in 24-carat gold
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Installation views
Photos Riccardo Pareggiani



To Breathe

The interrelationship between the rules of life in this world comes through plants. Plants are like the organs of people. Without them people can't get any air into their lungs.
Joseph Beuys

To Breathe is a series of works on paper, which portray plants that coexist with toxicity, using new technologies and old scientific processes of botanic image making. The pieces chart the changing depictions of plant toxicity in observational technologies from the 18th century to the present day. Using air-borne pollutants collected by the JRC scientist Jean Phillippe Putaud, I am creating images of plants I collected from the summit of Mount Etna, which have the ability to sequester air-borne pollutants.

This series is about the plant world's unmistakable connections to human survival – something we are facing in the wake of climate change. Today more than ever, plants will be our guides, representing the lungs of the planet and life amidst possible desolation. The idea for *To Breathe* was born on the site of Mount Etna where two of the volcano's endemics, Rumex Scutatus and Saponaria Sicula, which are closely related to Irish wildflowers, have miraculously adapted over time to withstand the harshest environments of Etna. They are pioneer plants on new ash fall that have the unique potential to sequester carbon from the atmosphere in the absence of soil (which is ultimately redeposited as carbonates in the ocean).

In June 2018, after I visited the JRC, I went to Mount Etna with a group of Irish scientists to unlock some of the codes held in the chemical makeup of the rocks and plants to research the genesis of this project. The remarkable fact is that these two plants, Rumex and Saponaria, have the ability to survive on ash and in extreme environments at the summit of one of the most active volcanoes in Italy. Each root tip continuously detects gravity, temperature, humidity, light, pressure and the presence of toxic substances (poisons, heavy metals, sound vibrations and carbon dioxide).

Spectrum

My research with the JRC extends to an exploration of how volcanic activity can change the light spectrum as well as impact the air, inspired by Edvard Munch's painting *The Scream*. In May 1883, the volcano on the tiny, uninhabited island Krakatoa, nowadays in Indonesia, showed signs of activity. By summer, loud noises and glowing clouds were reported.

On 26th August 1883, the volcano began to erupt and the next day, it exploded in one of the deadliest volcanic eruptions in modern history. Nearly 40,000 people on nearby islands were killed. Some burned to death. Others died from suffocation. Many were killed by tsunamis caused by the violent eruption. During a particularly powerful eruption such as this, volcanoes shoot fine particles of ash into the atmosphere, which cause sunsets to appear abnormally crimson for up to three years.

At the time of writing this, I am on residency at *The Institute of Athens* to study a rare archive consisting of hundreds of paintings of sunsets from 1500 onwards. The Great Masters reliably captured this effect by altering the red-to-green ratio in their sunsets after large eruptions. My collaborator Christos Zerefos, from Greece's Atmospheric Physics and Climatology Academy, spent two decades studying the paintings of Turner and others for signs of volcanic activity.

Inspired by this, I have been sifting through data vaults of solar activity to transfer this scientific knowledge of optical phenomena and insights into this project. After looking through hundreds of thousands of computer files, made accessible via open access archives, I am interested to bring together ideas of some of the sun's finest unseen moments of how the spectrum has changed in the last fifty years. These images have been kept in their most raw form, revealing the energetic particles and solar wind as a rain of white noise.

Siobhan McDonald,
Still of *Breathe,*
2018-2019

Setting the scene

Claudio Margottini

Setting the scene, at the border between art and science

Water gnaws at mountains and fills valleys.
If it could, it would reduce the earth to a perfect sphere.
Leonardo da Vinci (1478-1519)

Landslides represent one of the most evident manifestation of the continuous evolution of our earth's surface. This evolution is an incessant process, often imperceptible and limited to soil erosion, at other times with dramatic impact, especially when the volumes involved are considerable and affect humans and their constructions. Humans have, for this reason, always interacted with landslides, especially in the more mountainous territories, where susceptibility to landslides is higher; in a continuous challenge between adaptation to the natural environment and protection from these disasters. The main factor is clearly rain, and to a lesser extent seismic events, even if the anthropization policies of the territory have strongly contributed to this process. On the one hand, these policies generate landslides in areas where these were not present; on the other, they amplify the impact on the newly built fabrics of society.

As a consequence, in modern era landslides represent a major threat to human life, property, buildings and infrastructure, as well as natural (humanised) environments, mostly in the mountainous and hilly regions of the world.

From a geological point of view, a landslide is a (gravitational) downslope movement of rock, soil, debris, or a combination of them both, occurring on the surface of a rupture — either curved (rotational slide) or planar (translational slide) — in which much of the material often moves as a coherent or semi coherent mass with little internal deformation. It should be noted that, in some cases, landslides might also involve other types of movement (e.g. rock fall) either at the inception of the rupture, or later in case the landslide's properties change as the displaced material moves downslope[1]. From a physical point of view, landslides convert potential energy into kinetic energy and are thus important agents of topographic change and landscape evolution[2]. They are de-formations of earth's surface that reflect patterns of seismic, climatic, and lithospheric stress fields on sloping terrain. Landslides are basically described by two characteristics: (1) the material involved (rock, debris, engineering soil/earth) and (2) the type of movement (falls, topples, slides, spreads, flows)[3]. A proper classification based on the above elements, e.g. rock-fall, debris-flow, earth-slide, facilitates the understanding of the failure mechanism.

Landslides are also categorised as shallow or deep-seated. Shallow landslides have a vertical extent of up to a few meters and a horizontal extent of up to a few hundred square meters. Formation of shallow landslides mostly occurs in response to extreme rainfall events and depends on near surface structures and processes. Deep-seated landslides have a vertical extent up to several tens of meters and spread horizontally from a hundred to a few thousand square meters. They are distinguished into fast moving and creeping landslides[4].

The occurrence and reactivation of landslides are conditioned by a number of contributing factors related to bedrock and soil properties, including slope morphology, relief energy or land-use cover. In Europe, most catastrophic landslides are associated with heavy and/or prolonged rainfalls, coupled with soil erosion on mountain slopes. Other important triggering factors include earthquakes, snowmelt and slope toe erosion by rivers or sea waves, thawing mountain permafrost, volcanic eruptions, and man-made activities such as slope excavation and loading, land use changes, blasting vibrations or water leakage from utilities[5].

In more detail, short-term triggers are heavy rainfall events, saturation of the most surficial soil and groundwater flows, and pressure dynamics, but they can also include riverbank or hill-foot erosion during flood events, depending on site conditions. Long-term triggers include seasonal changes of the self-load, due to seasonal soil moisture variations and snow cover, and the contribution of trees and infrastructure to the self-load[6].

Landslide distribution on the earth

Since landslides are phenomena connected to gravity, they are mainly concentrated on areas with high slope angles (i.e., mountains) and characterised by debris, soft rock and/or engineering soil/earth. Clearly different slopes are required for various typologies of mass movements for the various involved materials. Referring to the triggering mechanisms, rainfall-induced landslides are a common and significant source of damages and fatalities worldwide.

A second group can be associated to seismic-induced landslides. The interconnection of the above elements (materials, slope and triggering factors) can clearly identify the regions that are most prone to hazard in the world[7]. In each of these cases, it is important to recognise that landslide types vary in relation to local and regional conditions. Thus, the above concepts are just a preliminary statement and first level of interpretation. Indeed, landslides can occur virtually anywhere in the world. Excessive precipitation, earthquakes, volcanoes, forest fires and other mechanisms, and more recently, certain dangerous human activities are just some of the key causes that can trigger landslides. Similarly, landslides are known to occur both on land and under water; they can occur in bedrock or on soils; cultivated land, barren slopes and natural forests are all subject to landslides. Both extremely dry areas and very humid areas can be affected by slope failures, and most important, steep slopes are not prerequisites for landslides to occur. In some cases, gentle slopes as shallow as 1–2 degrees have been observed to fail[8].

Landslides and climate change

Anthropogenic climate change is expected to increase the mean temperature and to alter precipitation patterns in the future. Precipitation patterns are expected to be more spatially variable, with decreasing precipitation i.e. in the Euro-Mediterranean area and increasing precipitation in central and northern Europe. Moreover, the intensity of precipitation extremes, which has already increased over the past 50 years, is projected to become more frequent[9]. Since heavy rainfall events are frequently triggering factors for landslides, the following trends can be assumed[10]:

- increase in the number of debris flows from high intensity rainfall, together with soil erosion and degradation phenomena, as a consequence of increases in temperatures and aridity;
- decline in activity for slow landslide phenomena due to the drop in the total average annual rainfall and the consequent decrease in the recharge capacity of the water tables;
- increase in deformations of slopes (rock falls due to freeze thaw, debris flows, earth flows) in areas which are now covered by permafrost and therefore substantially stable, following progressive increases in temperature and the consequent reduction in permafrost and glacial areas.

Mitigation of landslide impacts

Landslides result from complex interactions between geological and other triggering factors of different origins. Some of these factors cannot be influenced; others such as land cover or slope excavation, however, provide important opportunities for preventative measures. These include land use planning and management, or structural ones (rockfall nets, dams, rock clearance, etc.) as well as biological countermeasures (green engineering, protection forest). Generally speaking, landslide management should follow the principles of integrated risk management, thereby making use of all potential measures and integrating all stakeholders. Apart from the above general statements, major options to reduce landslide impacts, measures should include at least the following[11]:

- restoration of rivers, slopes and coasts, recovering as much of their functionality as possible. This process should include proper land use management at the catchment scale;

• prioritisation of interventions with low environmental impact;

• development of emergency plans;

• establishment of monitoring networks for the activation of alert and alarm systems;

• relocation of very high-risk settlements;

• definition of priority interventions and concentrating site consolidation funding on priority locations;

• development of inter-institutional cooperation, activating all possible synergies and respecting respective roles and missions.

A special case: Cultural Heritages, landslides and traditional knowledge

Protection and conservation of cultural and natural heritage sites is one of the most challenging problems facing modern civilization. It involves a variety of factors ranging from cultural and humanistic to technical and economic factors that are inextricably intertwined. The complexity of factors influencing the protection of cultural and natural heritage sites covers a broad variety of disciplines involved in this topic. Especially when natural phenomena, among them especially landslides and related slope phenomena pose a risk to cultural and natural assets, the experts from natural and technical disciplines are dealing with this serious problem, from earth scientists with various specialisation such as engineering geologists, geomorphologists, geophysicists, etc. to geotechnical engineers.

Moreover, various conference throughout the world confirmed that the problem of vulnerability to landslides of cultural and natural heritage sites is an emerging issue still to be properly investigated. This requires a multidisciplinary approach and highly qualified expertise in order to preserve the integrity and authenticity of unique natural environments, geo-sites, pre-historic sites, earth/rock monuments, archaeological sites, and historic urban landscapes. Within this broad view, the solutions adopted, as well as the necessary investigation and monitoring, are all aimed at minimising the impact of final conservation works, during study phases and execution works. On the other hand, reliable and accurate data are required to elaborate correct geological and geotechnical models in relationship to slope failure and instability, in order to achieve, together with historical and archaeological data, the most appropriate mitigation actions. The major outcome of this new school of thought are the many mitigation projects against various geo-hazards. Scope is to maintain the integrity and authenticity of the heritage site through a highly scientific investigation coupled to a monitoring

Leonardo da Vinci,
A mountain landscape, c.1505-10
Royal Collection Trust/Ã‚Â©
Her Majesty Queen Elizabeth II 2015
Source: public domain.

of the natural processes, in combination with a conservation project based mainly on traditional knowledge and sustainable practices. Traditional knowledge not only covers the use of traditional materials but also the recovery of long-established techniques and expertise, with local roots, mainly with a view of ensuring the capacity of the local population to maintain conservation works over time.

There are many concerns as to the future, especially in those countries where budgets are too low for financing preliminary studies which prepare for this new kind of hazard and mitigation strategies and risk preparedness (including for historical ruins/sites with buildings and, generally, natural sites). In those cases, the risk of landslides remains unmitigated, and thus the possibility persists of losing important heritage of the world's natural and cultural history that should be preserved for future generations[12]. Finally, in some cases, landslides can be also the mechanism for a heritage landscape, such as the case of isolated peaks and crests where humans, mainly for defensive purposes, settled their built-up area. Italy is very rich in such localities, as in case of Craco, Civita di Bagnoregio, Orvieto and many others. Also, landslides can be the inspiration for a heritage. A unique case is the Monsters' Grove of Bomarzo (Central Italy) where the debris of a large rock fall have been sculpted and finished in the shape allegoric statues, with a very high artistic value[13].

Conclusion

Landslides are complex phenomena based on the interaction of various factors including material type, bedrock, slope and triggers such as heavy rain-fall or earthquakes. They represent of the evolution of the earth's surfaces. A continuous process, often not perceivable, sometimes limited to the erosion of the soil; other times with dramatic impact, especially when the volumes involved are considerable and impacting on humans and built structures. Even if they are a very localised phenomena, the result of their action has global impact.

Humankind has therefore always interacted with landslides, in a continuous challenge between adaptation to the natural environment and protection from this, especially in the most mountainous territories and with land susceptible to mass movements.

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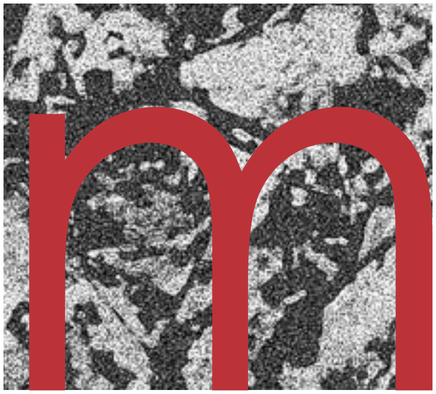

maze

A maze is a maze is a maze, turn left-right right-left get lost anyway, corridors of digital, endless loops of fake, viruses in mirrors fluid mobiles dangling, no exit no way out of digital dreams, take then a landslide, economy earthquake, money barbarism, coloured figures dancing in the wind, no equality no future, or dancing on shores waves upon waves upon waves like seven green tigers, looking for community, or more sedate vibrations, singing stones and singing metals, patterns age-old settling as DNA information in matter, if we are lost how will we cross this maze?

The maze is wandering in digital vistas, weird visions of AI art, the agoraphobia of the net, the claustrophobia of social media, malware speeding under your fingers on the screen, pullulating landslides scarring landscapes and communities giving rise to new resilience, a shifting heritage running through our fingers like sand, economic landslides burying lives under tons of privations, ferrofluid patterns of wanderings, the new coming up new shores, migrating dreams and despair, pushing horizons lives matters lost, patterns unfolding in sand, old DNA of dust rediscovered two hundred years ago, the maze of life scratching our irises, flee turn corners in a labyrinth of loss, maze of migration mirroring a mazement of maybe marvels?

Why am I Seeing This?
between systems and selves

Landslide

The Sound of Waves

Life is Motion

“Why Am I Seeing This?”

Artist
Ivana Tkalčić

JRC Scientists
Stéphane Chaudron
Nicole Dewandre
Ian Vollbracht

"Why Am I Seeing This?",
SciArt Datami project 2019
Video installation, 4 synchronised videos,
duration: 09:30 min

Images on this page
and on the next pages:
”Why Am I Seeing This?”,
Resonances III Datami
Festival JRC Ispra site
15 October–8 November 2019
Stills Ivana Tkalčić

"Why Am I Seeing This?"

Ivana Tkalčić

An Excursus
Background and motivation

From my point of view, it is important in the field of artistic research, to connect many different practices and theories, as well as media, and to exchange acquired knowledge with others in the community, involving them in the process.

I participated in the residence programme *Artist-in-Resonance*, coming to Ispra for two weeks in an agreement with "fellow" scientists. The residence was divided into two periods of one week. The first week was from 11th until 15th February, in Brussels and Ispra, and the second week was from 13th until 17th May, in Ispra.

During the first week, I met with Nicole Dewandre in Brussels, and discussed with her the topic of "how it is to be human in a hyper-connected era". Later that week, I met with Ian Vollbracht in Ispra, consulting with him on the topic of "social media targeting and filter bubble".

The second week, I focused on meeting with Stéphane Chaudron, talking about "identities in the digital world".

In the process of researching the topic, some questions emerged for guidance and support during the conversation with the scientists. Through questions, it is possible to follow the thinking process and changes in development of the project:

To Nicole Dewandre

- In the Onlife Manifesto[1] it is said that the ICTs (Information Communication Technologies) are affecting who we are, how we socialise, our concept of reality (our metaphysics), and our interaction with reality. How do ICTs / technologies shape us as humans, while we humans shape technologies?
- In the Manifesto, it is stated that the current conceptual toolbox is not fit to address new ICT related challenges anymore. What should the new toolbox contain?
- How is the status of ownership (especially with regard to personal data-apps that can record our vital signs/everyday routines, our search history, etc.) and connected to that, privacy in a hyper-connected era, possible? Who should regulate ownership of the data?
- What do you think with regards to the use of filter algorithms in order to present personalised browser information to users on the web? Would this affect plurality in the sense of Hannah Arendt's plurality, and is plurality necessary for the relational self?
- Nowadays, Yuval Noah Harari, a popular Israeli historian, and professor in the Department of History at the Hebrew University of Jerusalem, suggests that the next quest for humankind is to reach immortality, achieve bliss and become Homo Deus, a human god. How achievable is this endeavour in the hyper-connected era? Is it necessary? And what do you think about the kind of human project we are working on or should be working on?

To Ian Vollbracht

- Today we can say, just as Harari did, that data is the most important asset in the world, but who owns this data? If it's our personal, biological data, do we really own it, or is it the property of corporations, governments, or the elite? When did we become product?
- While being overwhelmed by all the advances in computer science, machine learning, biology and brain science, we can come to the conclusion that computers know more about us than we do ourselves. Some conclusions in recent years have been that living organisms, including human beings, can also be seen as algorithms and can be thus reprogrammed (manipulating human biochemistry and life, just like processing data). Do you think that's true?
- It seems that this statement, that human beings are algorithmic, goes hand in hand with tools used in psychological targeting/social media targeting. Where does the idea of making a "free choice" and human sense


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STBY電池的靈壓...
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fit in here? Is it possible, in this hyper-connected era, to be in control of your own personal data/life?
• Maybe we can conclude that social media targeting and psychological targeting can be used in manipulating and predicting decisions we will make before we make them. The computer algorithms in that sense can label us as having specific psychological traits and then include or exclude from different information/goods/services etc. Maybe the Social Credit System which is used in China is not far from emerging somewhere in Europe too, or can we argue that some elements do in fact already exist?
• Internet technologies are being used in ways that raise far-reaching questions about the resilience and sustainability of democratic systems. In a far or not so far future, if Europe becomes a digital autocracy, where information and decision making is mostly done by one entity, the machine and its algorithms, where would democracy lie?

To Stéphane Chaudron

• How is the current context of digital world affecting who we are, how we socialise, our concept of reality and our interaction with reality, in other words, shaping and changing our identity? What are researchers' findings in those regards?
• How easily are children influenced by following certain trends, and how are they being manipulated online? Did you come across some examples of negative and positive trends of online influencing their everyday behaviour?
• What are the biggest challenges for children and teenagers in forming their identity in the digital world compared to the physical world?

Research rationale and related studies

As W.J.T. Mitchell said, images have always been with us, including the image of the world. At different times and different places, there are different images of the world. That is why history and comparative anthropology are not just descriptions of events and practices, but also representations of events and practices. Images can change reality to the extent that revers-

es the logical, blurring the difference between real and reproductions. We naturally believe in their reality, but they only apparently resemble things, events, and persons.

The notion of "the real" is even more debated in an era when the highly optimised interaction loops, personal news feeds, bots, automatically generated content, fake news, possibility to immerse into an augmented reality and ever-getting smarter AI are challenging the very nature of "reality" and shaping new conditions of human perception.

Our perception and the experience of the world has, and is, undoubtedly changing. Marshall McLuhan already foresaw the effects that media such as the internet will have on human conditions and perceptions, by changing the human environment.

In the *Onlife Manifesto*[2], which was the outcome of the Onlife initiative, it is stated that information, communication, and technologies are affecting who we are, how we socialise, our concept of reality (our metaphysics) and our interaction with reality. But how is information, communication and technology shaping human perception (while we humans shape technologies) and into what?

The digital transition places us into a world where nature is imbued with sensors, machines, and devices. The experience of the surrounding world is becoming talkative. An animated nature, where it becomes difficult to distinguish between what is naturally given, and what is fabricated.

As Peter-Paul Verbeek argues in his book *What Things Do*[3], "the knowledge that we have of reality is a product of consciousness" and "the knowledge that we have of reality is a mirroring of the world itself". So, we can say that humans continually experience their world and have a constant relation with the world in which they realise themselves.

In her book *The Wretched of the Screen*[4], Hito Steyerl points out that "the new context establishes a new visual normality" and continues "the former distinction between object and subject is exacerbated and turned into the one-way gaze of superiors onto inferiors, a looking down from high to low."

According to Hannah Arendt in *The Human Condi-*

tion[5], the new technological advancements alienated humans from their immediate surroundings. The technologies she presents and even argues for, mediated and transformed the way in which we perceive reality and the world. Arendt perceives the role of technologies in the sense of the alienation provoked by Galileo's telescope. Arendt's statement on the need for the world to embrace plurality and natality is a necessity for inclusive development of new human perception, related to the question of new developments in technologies[6].

Research focuses

The capabilities for communication and connection through digital platforms, and the possibility to easily access information, are one of the biggest advantages in our everyday lives. Rich social relations and information abundance that emerge from the platforms, are also giving another advantage of easier community building on the fly via personal broadcasts. There are now more than 4 billion people around the world using the internet[7].

It is estimated that for every person on earth, 1.7 MB of data will be created every second, which is an increase of 50 % of data growth in the year 2018. The amount of time that people spend on the internet has also increased –around 6 hours each day per user; or in total one billion years spent online in the year 2018. The global number of people using social media has grown by 12 %, and the e-commerce market for consumer goods grew by 16 % in the past year[8].

Worldwide, human life redirects towards the online world, where the new world-view is in the making, witnessing the circulation of data in enormous quantities. In his book, *Homo Deus: A Brief History of Tomorrow*[9], Yuval Harari states, “data is the most important asset in the world”, which is why it is necessary to question the way data usage and ownership are handled. If it is our personal data from an online presence, offline movement, or even our biological data[10], is it possible for us to direct it ourselves? Or is someone else doing it for us?

For example, if we look at our daily online communication. Nowadays, it is not only happening through

text messages, but also through images, videos, GIFs, twitter posts, blogs, games, Skype and group chats. Even if we are far away from our friends and relatives, we can still connect as instantly and vividly as almost being physically present. On the other hand, all that data is leaving a digital footprint that can be followed to the source and be potentially misused.

Networks have redistributed and expanded the viewing space. Moreover, most of the digital platforms that we use every day are not only collecting information about us as users, but are also filtering all the accessible information according to "our" needs, and showing the material they think would be of our best interest, guided by the principle of "If you like this, you will like that too". When a computer algorithm wants to recommend something to a user, the most logical thing to do is to use the user's information based on location, past click-behaviour, search history, type of owned computer, and also to find out what people with similar interests like, by analysing their behaviour, and recommending the same items. For example, it can look at items the user bought earlier, and recommend similar products. We, as users, may have the feeling of the useful, personalised, everyday landscape, individual decision making and freedom of choice, but all that can be part of our own personal bubble world – a comfortable illusion.

Adding to that, to better understand the way the online environment functions, we should keep in mind that, according to a group that monitors internet freedom – Freedom House's report, which focuses on developments that occurred between June 2017 and May 2018 – internet freedom declined in 26 countries, while only 19 countries improved their score. As a result, just 20% of the global internet population is considered to be "free".

Regarding all the new visual material, it is often hard to be sure what we are seeing when we look at today's world. Through our bubble vision[11], we are assembling a world from pieces, assuming that what we see is coherent and equivalent to reality. The problem with bubble vision is that users are in intellectual isolation, in a so-called parallel information universe, which feeds on itself.


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bogdanroyyb !gamble 15
iamchineese !gamble all
Streamlabs Rolled 34, @iamchineese lost 2463 Points
Points
118
XYZ -3,451,956.1, 62.6, 37,78
West -X (90.0, 9


Please stand by
The regular
programming
will resume shortly


N O W
that's what I call
T R O L L I N G

As a result, users are isolated from information that contradicts their viewpoints, effectively isolating them in their own cultural or ideological bubbles. Furthermore, when we make choices about what information we focus our attention on, we choose according to certain unconscious criteria. Big Tech inventions are trying as much as possible to hijack and hold on to our conscious attention, while the latter could in fact be the final line of defence in an attempt to preserve our enabling of private thoughts and conscious actions.

The information and the images that we see are becoming our perception of the world, our point of view, our understanding of reality – the foundation for thought and action.

Research questions

• How are Information, Communication, and Technologies changing and shaping human condition, consciousness and perception, while humans shape Information, Communication, and Technologies?
• How has the everyday online–offline interaction changed the experience of the world around us and influenced our daily visual perception?
• Is human vision becoming a one-dimensional feedback loop?
• Where does the idea of making a “free choice” fit in the new context of online psychological and social media targeting? Is it possible in this hyperconnected era to be in control of your own personal and biological data?
Have we become a product?

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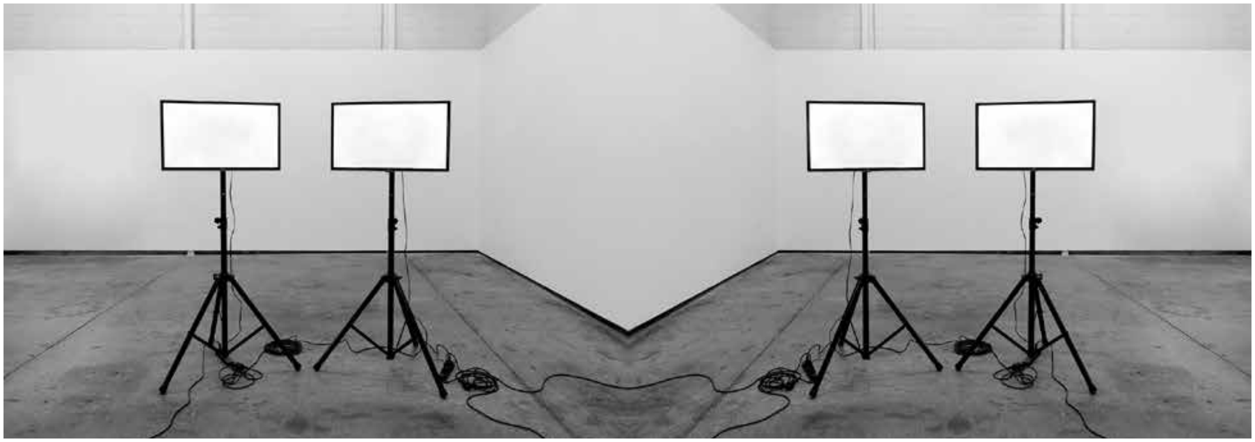
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation site of *"Why Am I Seeing This?"*
Footbridge between the buildings 26a-100
Photo Cristina Fiordimela



"Why Am I Seeing This?",
Resonances III Datami
Ivana Tkalčić*,*
Installation study*,* 2019

between systems and selves

Artist
Caroline Sinders

Scientists
Stéphane Chaudron
Henrik Junklewitz

between systems and selves,
SciArt Datami project 2019
Sculpture: polymethyl methacrylate, nylon thread, wire mes

between systems and selves,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view
Photo Caroline Sinders

between systems and selves

Caroline Sinders

Inspired by the work of Alexander Calder and Giorgia Lupi, *between systems and selves* is a series of poetic sculptures, designed to make malware and algorithms readable for humans. So much of code plays with literal human words but uses technical processes that are hard to describe. An algorithm can do things, but why it does things is due to the math that is within the algorithm.

Malware, much like algorithms, is an extremely technical concept that affects every person. Malware viruses are pieces of code designed to exploit, hurt, and target systems, systems that often include critical infrastructure or factories (such as the Stuxnext virus). They also attack open wifi on IOT devices to take down websites such as Netflix, Facebook, and others (such as the Mirai botnet). Some of these viruses then adapt and create new malware viruses (again, such as Mirai). But moving beyond what malware is, the act of explaining it, is very similar to AI and Big Data. These concepts are extremely difficult to grasp (even for seasoned researchers), but all deal with data, technology, and human interaction. To compare malware, you still need a series of algorithmic analysis. The way to artistically intervene with malware is very similar to how one could artificially intervene with AI, which is made up of data and algorithms. Our sculptures are our poetic descriptions, and evaluations of malware. Hanging from the ceiling, and rendered in transparent and blue colourings, these 100 sculptures representing 100 different malware files, are fluid mobiles. By hanging from the ceiling in a rectangular grid, they allow the audience to grasp how the viruses are related, as genii, to each other, but also exist as individual viruses.

The process

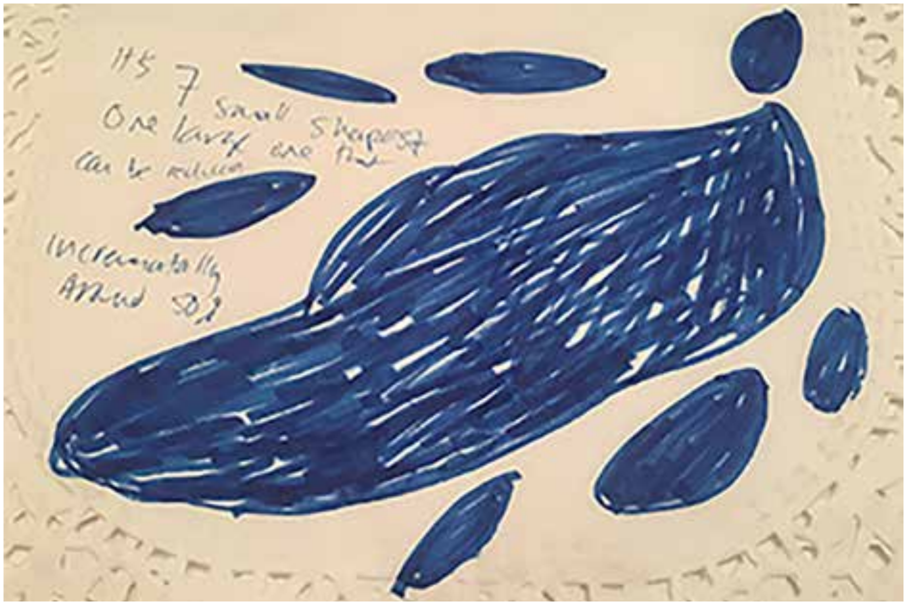
The overall process of being an artist with the Datami and JRC SciArt initiative on Big Data and algorithms has been interesting and eye opening. There are so few funded fellowships, residencies or opportunities to work in the field alongside practitioners, scientists, and researchers. Structure is important, and creating parameters provided a great backbone and framework to help guide the ideation process between myself and my scientists.

We needed to grapple with what we could imagine versus what we could feasibly build for the residency. I mention feasibility, parameters, structure as not creating a tension with imagination and ideation, but rather, this structure creating a set of concepts to guide a cross-discipline and cross-country collaboration. Scientists work with facts that, together with research methods, guide their practice. One of the most fruitful, and challenging, aspects of this collaboration was the dance between fact and expression, which, to be honest, was my favourite part.

Working with scientists who deal in facts, who deal in what something very much is, what something concretely has been recorded as, provided a solid foundation for art as the translator for the poetics of fact. Working with Stéphane and Henrik has been an amazing collaboration. Our first two meetings were spent gaining an in-depth understanding of each other as researchers – what was to be found in our files, what did we want to say, what could we say, what could be explored or pushed forward. Once we came to those conclusions, we started to think about but what can we say and how can we say it through poetry?

Once we knew the facts or understood each other's data, we could then think about how the data should be rendered, and what should be said about the data. This is translation, and this is where our artistic process comes into play. We started looking at other data visualisation projects, and we captured our inspirations here on a website[1].

We really aimed to make something that wasn't just data adjacent, but really made malware a key com-

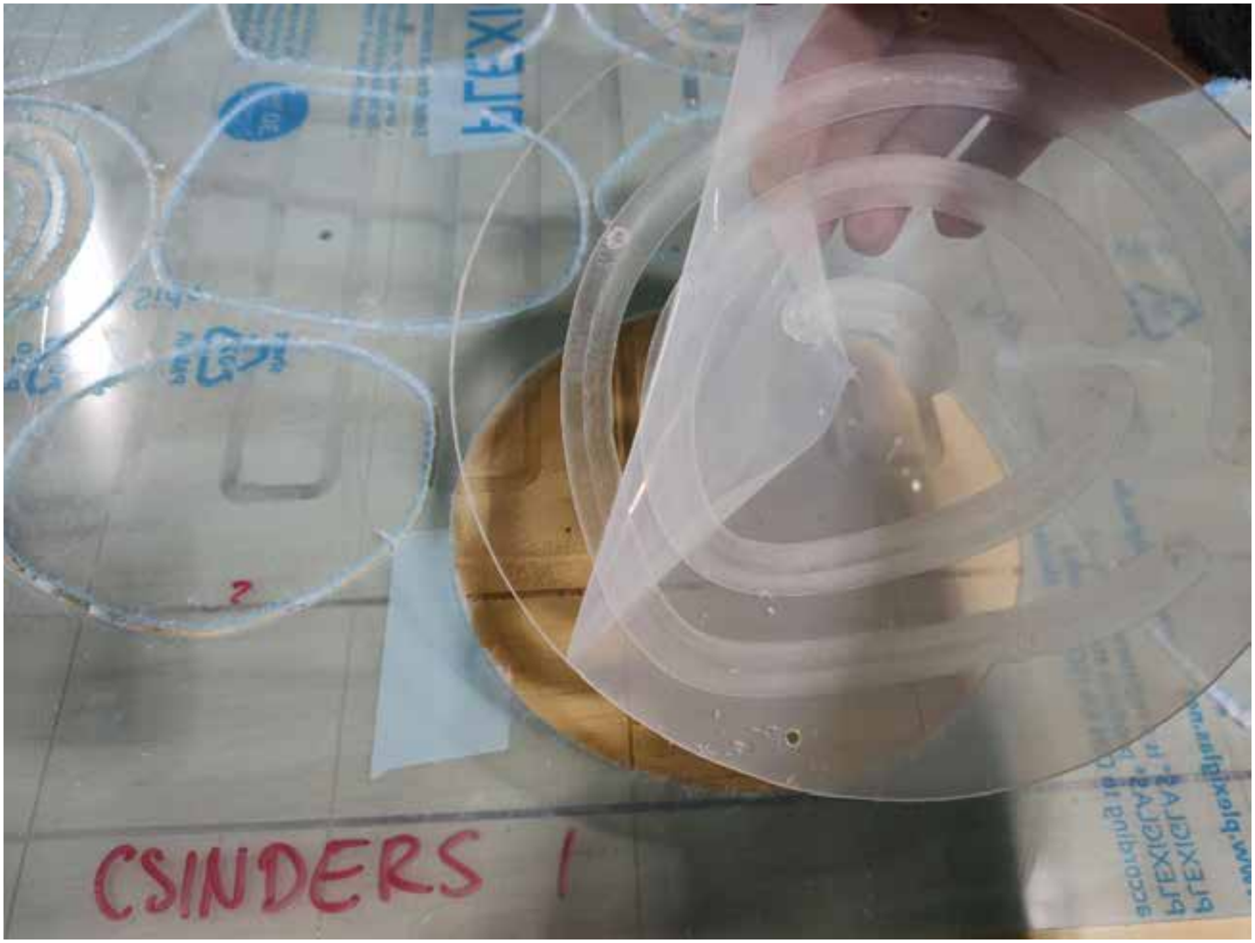


Caroline Sinders, *between systems and selves*, materials, 2019

ponent of the art piece. Henrik, Stéphane and I realised that we were incredibly passionate about elevating malware viruses to the more general public consciousness. Malware, which affects everyone, is hard to grapple with and understand because it is so technical. The "technical-ness" of malware is also what makes it so interesting, as researchers, and artists, to play with. Throughout the summer, I received a crash course in digital to physical fabrication, as well as cross-country logistical collaborations.

As an artist who has a research-based process but who very rarely creates physical manifestations of art, this summer forced me to learn and create a set of skills. But this "forcing" was entirely welcomed, and helped push my practice forward. *between systems and selves* is a dance between aesthetics and research rigor, which is a new kind of making for me. As an artist, my work often manifests as written word, performances, workshops or things that are ephemeral and experimental, but are rarely tangible. *between systems and selves* is the exact opposite of that, and delightfully so. This new form of work is the beauty of collaboration, of having the ability to make new pieces.

From June to August, I had to source materials and fabricators across the EU to help bring my JRC Datami vision to life. A data visualiser helped parametrically and mathematically translate my designs and vision into a template; we used a CNC[2] for our materials fabrication and had our materials fabricator cut almost entirely unique shapes into Plexiglas for our mobiles . Even back to myself, there was a by-hand process of adding necessary retouches, finalising sketches, and configuring our templates. The summer was one of hard work and love in order to bring this vision to life.



In June, I started creating image sketches focusing on malware and how malware affects physical society. I then began to paint and sketch over these images to make them less readable by ma-chines. These images are important to my process and exploration of the Datami.

between systems and selves,
Resonances III Datami
work in progress, 2019
Photo Caroline Sinders

Malware Sculptures Visualisation Guide

Graphical inspiration

Very Calderesque (the round things below) with some parametric influence. Most of the shapes should have a roundness to the edges, though one or two can be harder, sharper (more triangular).

We've created a key to unpack the shapes used within the sculptures. The shapes were directly inspired by Calder and organic matter. So much of malware analysis is inherently technical or mathematical, that these shapes make the purely technical now tangible and understandable. For example, an FS bucket is a metric used by the JRC, which stands for file system bucket, which is when the code was discovered.

Key

FS Bucket illustration: the FS buckets had multiple data points within them. We rendered the measurements as general circles, with smaller points within. The smaller lines that are curving are the measurements within the FS bucket.

Type of Malware: malware has many different "types" based on what the malware is designed to do. Some malware is designed to be hidden and represent itself as another kind of code (like a Trojan), others are designed to do something particular- like measure keystrokes (such as the keylogger). The shapes for malware type pull directly from sketches and shapes used by Calder in his own work.

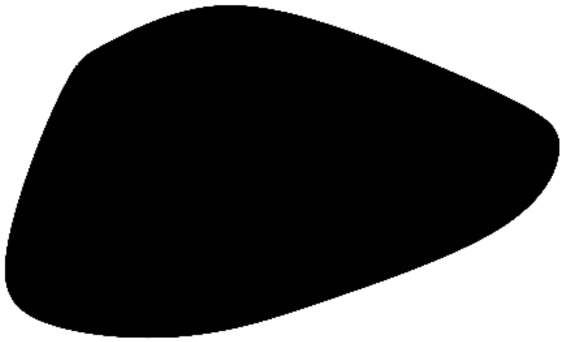
Trojans

Keyloggers

Worms

Ransomware

Bitcoins
[half of a circle, like half of a coin]



File Size: this shape grows larger and smaller based off how large the malware file is and how long the code base is.

Tests: this shape and smaller shapes correlate to tests. There are 57 tests. When malware code passes under 50 tests, it stays this one shape, but when it surpasses 50 tests, a small, new piece appears. A shape could be a singular shape or have a large shape with up to seven smaller shapes, to visualize the 57 tests. The shape here shows 55 tests passed. These tests are to see if the code is malware - there are 57 different tests to determine if code is malware.

Datami 2019 – My experience as a scientist

Stéphane Chaudron

I was introduced to Caroline's work for the first time at the Datami summer school in June 2018, when I was immediately taken by her approach to subjects and research questions. First, because I could make mine most of her questions, as our research projects on data and social interactions in the virtual world were close to each other. Second, because I found Caroline's creative work either intelligently provocative or highly poetic but above all, very effective in triggering further thinking in the audience.

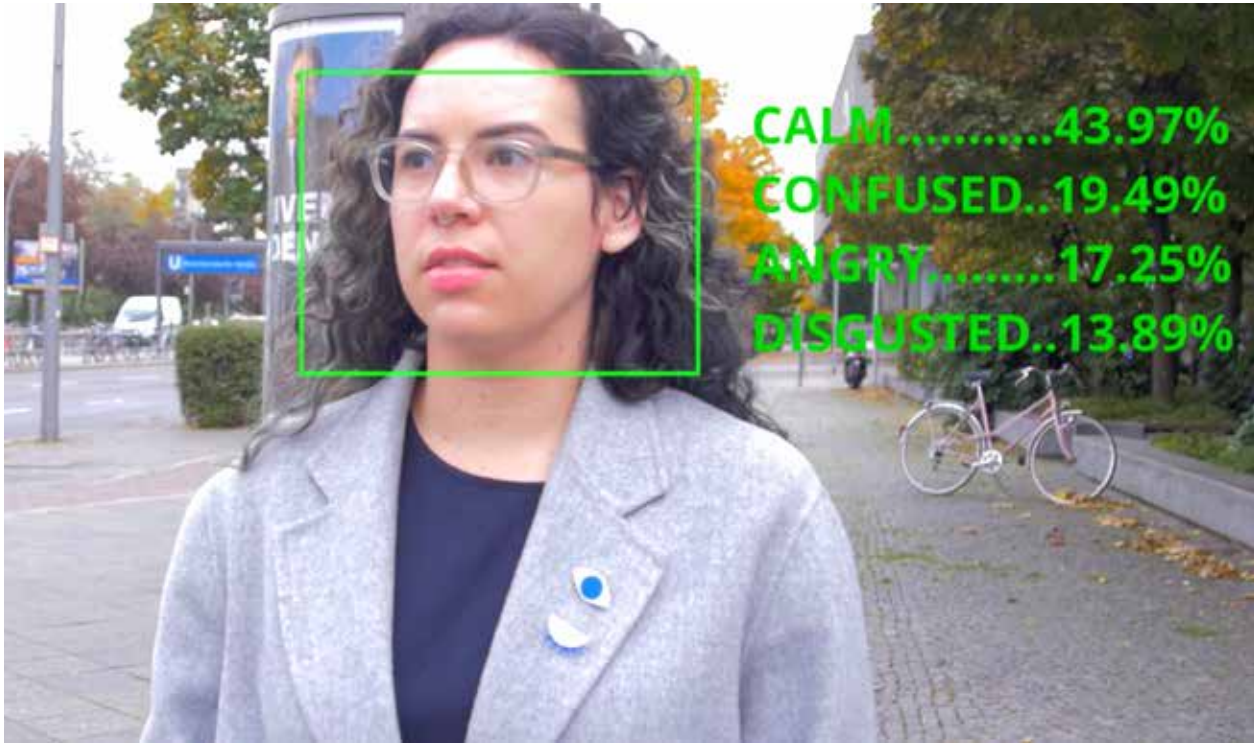
Together with Henrik Junklewitz, a machine learning expert, we discussed intensely and deeply from day one, and I embarked with shared enthusiasm in this unusual research project. Yes, the project was unusual for JRC scientists, but the process was familiar: defining aims and research questions, defining data sets to work with, analysing them and finding ways to communicate the results effectively.

Probably the main difference with my everyday research lay in the freedom that fuelled the process: questions, aims, visualisation choices, all of which was up to us. Nothing, or very little, was written up in the beginning. We allowed the flow of our collaborative thinking to guide us. Our complementarities precipitated rich brainstorming sessions, producing multiple scenarios and several iterations. While doing so, the process pushed the boundaries and limits of my knowledge. For example, when I looked back at my meeting notes with Caroline and Henrik, I could see how this research process, notwithstanding its artistic aim and outcome, helped me to better understand some technical concepts that were less familiar to me – I had to find ways to explain, show or translate them. In addition, the entire project was an occasion to step back from my defined area of research and look at it from a much more global perspective, with a more human-centered approach.

The entire experience was electrifying for me. Creativity and lateral thinking were boosted after each of our regular collaborative working sessions and I could feel these effects lasting for some time once back behind my screen, immersing myself again in my everyday work. Now, I am very curious to see how Caroline has translated our work into a visual, mobile creation, but actually, for me, as the saying goes, "the journey mattered more than the destination".

Notes

1 https://www.are.na/caroline-sinders/jrc-inspo.
2 Computer numerical control [CNC] is a method for automating control of machine tools through the use of software embedded in a microcomputer attached to the tool. It is commonly used for manufacturing machining metal and plastic parts. Definition from https://searcherp.techtarget.com/definition/computer-numerical-control-CNC [accessed 18 September 2019].



A still from the video
Anger Disgust Fear Happiness Sadness Surprise,
by Caroline Sinders
Resonances III Datami
Exhibition BozarLab, Brussels
10 December-19 January 2020

Landslide

Artist
Tiny Domingos

Scientists
Luca Barbaglia
Francesco Mugnai
Pierre Pegon
Tullio Ricci [INGV]
Luca Tiozzo Pezzoli

Collaborators
Gerlando Errore, Structural engineering
Cristina Fiordimela, Design

The Price of Volatility,
Datami SciArt project, 2019
Installation, 31,20 x 6,22 x 4,50 m, boat sail,
jersey barriers, steel structure and cables

Landslide,
Datami SciArt project, 2019
Analogy between data from European
institutions and from the landslide research
Various sizes, mixed media

The Price of Volatility,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view
Photo Ulrike Miriam Bausch

LANDSLIDE: /ˈlan(d)slʌɪd/ noun

1. a collapse of a mass of earth or rock from a mountain or cliff.

synonymes: landslip, rockfall, mudslide, earthslip, earthfall; avalanche

"the road was blocked by a landslide"
"floods and landslides killed several hundred people"

2. an overwhelming majority of votes for one party or candidate in an election.

synonymes: decisive victory, runaway victory, overwhelming majority, grand slam, triumph, walkover, game, set, and match

"they won by a landslide"
"the 1906 election produced a Liberal landslide"

Oxford Dictionary[1]

panta rhei: Greek quotation attributed to Heracleitus
Definition of panta rhei: all things are in flux

Merriam-Webster Dictionary[2]

"Qual è quella ruina che nel fianco
di qua da Trento l'Adice percosse,
o per tremoto o per sostegno manco,

che da cima del monte, onde si mosse,
al piano è sì la roccia discoscesa,
ch'alcuna via darebbe a chi sù fosse: (...)"

"Just like the toppled mass of rock that struck
because of earthquake or eroded props
the Adige on its flank, this side of Trent,

where from the mountain top from which it thrust
down to the plain, the rock is shattered so
that it permits a path for those above: (...)"

CANTO 12, Inferno (4-12) in *The Divine Comedy* by Dante Alighieri, 1320.
English translation by Mandelbaum[3]

"Cerco un centro
di gravita' permanente che non mi faccia
mai cambiare idea
sulle cose
sulla gente"

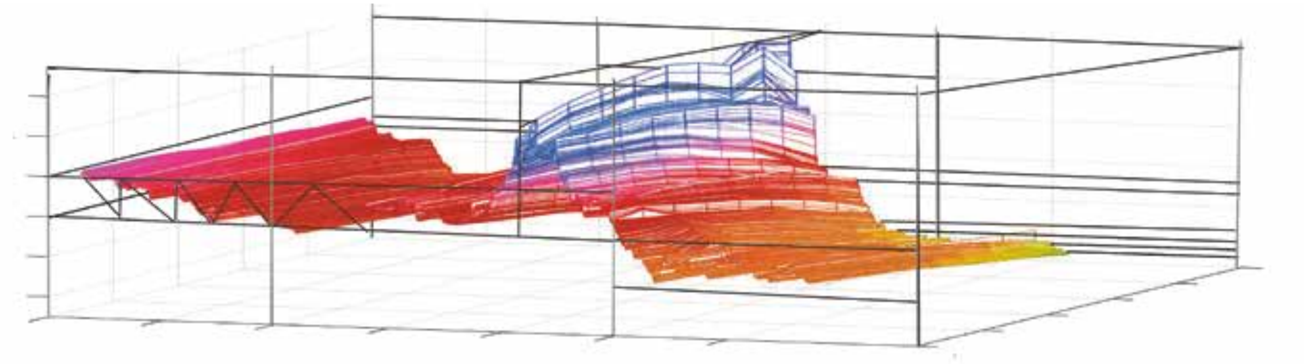
"I'm looking for a centre
of permanent gravity that will never make
me change my mind
about things
about people"

In *Centro di gravità permanente* by Franco Battiato,
Lyrics by Franco Battiato and Giusto Pio[4]

"Zurzeit gerät etwas ins Wanken"

"Something starts to falter"

Angela Merkel in the Bundestag, 04.07.2018[5]



The Price of Volatility,
Resonances III Datami
Tiny Domingos, drafts:
a long banner to recreate a 3D chart representing the 10 years evolution of maturity bonds of Portugal, Spain and Italy
Based on the evolution of maturity bonds in PIGS countries, the blue colour stands for the peak of the Euro Debt Crisis

Landslide

[Resilience in Unstable Times]

I. Background

The SciArt project *Landslide* combines contemporary art, econometrics and geomatics. It is based on a metaphorical analogy between the risks of natural disasters and the increased instability of the current international socio-economic and political system. This is marked, among others, by the climate crisis, international humanitarian, economic and financial crises, the rise of populism, nationalism and authoritarian regimes. Like in a landslide or an earthquake, the very base of liberal democracies seems to be wavering.

"The sound of a system that will collapse" [6]

The word "collapsology" is a neologism (...) composed of the word "collapse", from the Latin collapse, "which fell in one single block" (originally from the verb to collapse in English, "to fall, collapse, collapse ") and the suffix" -logy ", forming the name of a science, of the scientific study of a subject.[7]

Signs of time: prophecies of "imminent system rupture", catastrophic theories and works of fiction are multiplying. In 2015, Pablo Servigne and Raphaël Stevens published the book *Petit manuel de collapsologie à l'usage des générations présentes*[8], with the intention of "addressing the big issues of the current situation" that the best seller Collapse: *How Societies Choose to Fail or Succeed* by Jared Diamond[9] would have left out. In their handbook, the authors define collapsology as follows: "Transdisciplinary exercise to study the collapse of industrial civilisation and what could succeed it, based on reason, intuition and recognised scientific work". Several voices have risen, questioning the scientific legitimacy of collapsology. Critics point out the "fatalistic resignation"[10], the use of a "scientific patchwork" that drags the reader "on the slippery slope of catastrophism". However this *Petit Manuel* has turned into a striking editorial phenomenon in the francophone countries, having definitely contributed to establish the term collapsology in public discourse.

As for the field of apocalyptic fiction, Jean-Paul *Engélibert stresses in Fabuler la fin du monde: la puissance critique des fictions d'apocalypse*[11], that these works are very revealing of our times. The completion of the disaster (from Italian *disastro*, dis-astro: bad star) can have a liberating effect, by pulling us out of contemporary passivity in the face of the anthroposcene era, and by opening the doors to utopia.

II. Rocks in the Surf

Amidst this current turmoil, the EU continues to guarantee of peace, stability and democratic values. Combined, the Member States rank first (on the list of) world economic powers and international aid donors. At the Joint Research Centre of the European Commission[12], teams of scientists work on a vast range of research areas in a concentrated atmosphere of laboratories and offices. Many benefits for practical life in Europe are indebted to the projects developed in this science hub.

Valentina Paracchini, from the food safety team, develops DNA control standards to ensure food security against increasingly sophisticated fraud in the food sector, which amounts to billions of dollars each year.[13]

III. Lisbon Earthquake

The 1755 Lisbon earthquake is considered the first major disaster of modern times. The destruction of the city centre and the entire surrounding coastline inspired multiple authors from different eras.[14] Such as the German writer Heinrich von Kleist, who published his famous novel *Earthquake in Chile* (1807), in which a great earthquake totally changes the fate of its protagonists.

Having studied in Lisbon, I became aware of the constant fear Lisboans hold towards new and disastrous earthquakes. The particular geographical situation of the city, close to the fault line in which the Euro-Asian and African plates touch, increases the probability of seismic hazards.

At the European Laboratory of Structural Assessment (ELSA), earthquake-resistance tests are carried out on a large structure that represents a multi-story building - the largest of its kind in Europe. As would be the case of a reconstruction of Lisbon, the great challenge is to achieve a more resistant statics to earthquakes and other disasters (for example terrorist attacks or bombings) in today's buildings. These experiences captivate through their simplicity and efficiency. The know-how of the ELSA Lab has been directly used in the many artworks and civic infrastructure, built every year throughout the European continent.

Seismology was therefore one of the possible starting points for this project. The term "landslide" aroused my curiosity, as it was mentioned several times during scientific presentations of the 2018 Resonances Summer School. I often work starting from words and concepts, so I recalled a variety of related expressions from such a suggestive and inspiring term. Landslide studies are also undertaken by a JRC working group dedicated to the prevention of earthquakes, tsunamis, landslides and floods.

I wrote a first proposal in which two timelines intersected, the millenary, resilient, Mediterranean culture, rooted in science and technology, against the impact of natural disasters. The inspiration behind it was the curiosity to know, and make known, how theoretical and mathematical science, such as geotechnics, deal with the natural phenomenon of landslides in their multiple forms. Mudslide, rockfall, debris and earth flow – all of these are extremely destructive and difficult to predict. Once the project was approved, I started to converse directly with Francesco Mugnai, coordinator of the SciArt projects of the JRC and graduate in Geotechnical Engineering, with a specialisation in Geomatics[15]. He became the "fellow" scientist of the *Landslide artwork.*

IV. Italy. Land of Landslides

LANDSLIDE : "the movement of a mass of rock, earth or debris down a slope"
Cruden, D. M., 1991

Land of historic earthquakes, such as the 1783 Calabrian earthquakes or the great Sicilian earthquake in 1906. Land of famous volcanoes such as Vesuvius, Stromboli, Etna and the lesser known Phlegraen Fields. Italy is the European country with the highest risk of landslides, which are the most frequent natural disaster and could affect one million people.

In Italy, landslides have been known and feared by the public for centuries, and as such have become a theme in literature and art. The Italian poet Dante Alighieri was already mentioning this natural phenomenon in his *Divina Commedia* in 1321 (see initial quote). The long list of Italian landslides includes the deadliest of Europe: in 1963, the Vajont landslide killed about 2000 people. Yet these larger occurrences are rare compared to smaller landslides that often threaten individual buildings and infrastructure, damaging roads or railways.

The physical impact of landslides has a considerable economic consequence. Martin Klose[16] identifies Italy (US$ 3.9 billion) and Japan (> US$ 3.0 billion) as countries that experience the worst economic impact of landslides worldwide. With 0.19% loss percentage of GDP, Italy should be at the top of the world in terms of impact in proportion to economic performance.

The triggers of landslides vary from natural causes[17] to anthropic activities.[18] The National Institute for Protection and Environmental Research in Rome concludes that "(…) landslide phenomena have become a major problem with regard to the safety of the population and damage to residential areas, infrastructures, service networks, and environmental and cultural heritage."[19] They attribute this to increased pressure from humans on the environment with urban areas, infrastructure and transport expanding.

The Vajont disaster was caused by human activity, at a new hydroelectric dam. It shows precisely how human activity can trigger landslides, differentiating them from other geo-hazards.

Another unique feature of landslides is their large diversity in size, velocity, and lifetime. Their speed goes from slow (mm/year) to extremely fast (m/s). The different types of terrain, mountainous and flat, and their sometimes indirect relationship with other geomorphological, and anthropic factors contribute to the great complexity of this phenomenon. As a result, landslides require a global approach, involving various disciplines and sources for their understanding. An interdisciplinary outlook, in keeping with the SciArt perspective, which we pursued since the beginning of this project.

Introduction to Earth Sciences

During my stay at the JRC, I was able to focus on the various types of landslides, the issue of monitoring and mitigation, as well as the great challenges of geotechnics and geomatics. I learned about some in situ field studies and the sophisticated technology used. Among others: hyperspectral sensors, electromagnetic waves, 3D modelling, sensors processed by interferometry techniques, satellite radar data, laser beams, thermal images, inclinometers with which these scientists study and measure the landslides evolution. Equally interesting because of how it explores the relation between theory and practice is the use of mathematical formulas to develop landslide susceptibility models.

Landslide Occurrences

Discussions with Francesco Mugnai were intense and focused on a number of specific cases. Canossa, with a history of landslides from at least the 14th century to the present day. Volterra, one of the most important Etruscan settlements was affected by landslides and erosion in medieval times. The villages of Calitri, San Mango sul Calore and Conza della Campania were severely touched by the 1980 earthquake that caused landslides. The village of Conza was completely rebuilt 4 km from its original location. In Montaguto, the site of an ongoing landslide, due to heavy rainfalls a quick landslide in 2010 destroyed a railway line.

We also discussed the San Leo rockfall (2014), the erosion landslides of Orvieto, Pitigliano and Cività di Bagnoregio. In 2010, a landslide forced the displacement of about 1500 inhabitants of San Fratello, Sicily, a place that had already been devastated by the same phenomenon in 1754 and 1922. Between 1959 and 1972 several landslides almost destroyed Craco, in the province of Matera. The historic centre was abandoned in 1980 in the wake of an earthquake.

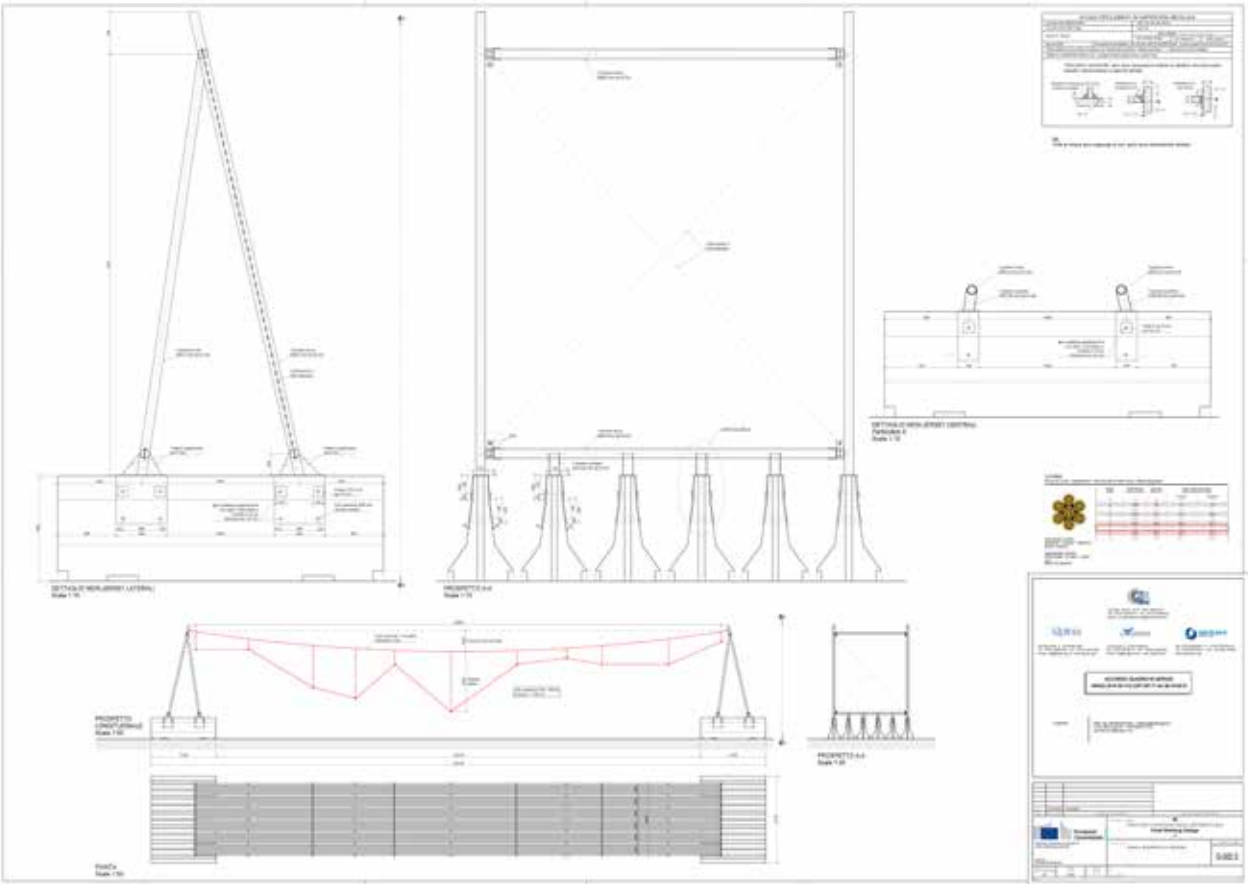
On 4th and 5th May 1998, 150 landslide movements spread over 75 km2 and devastated large areas of the city of Sarno (near Naples) as well as the neighbouring towns of Quindici, Siano and Bracigliano. This lead to the death of 161 people in only ten hours[20] and had lasting media echoes due to its alarming proportions.

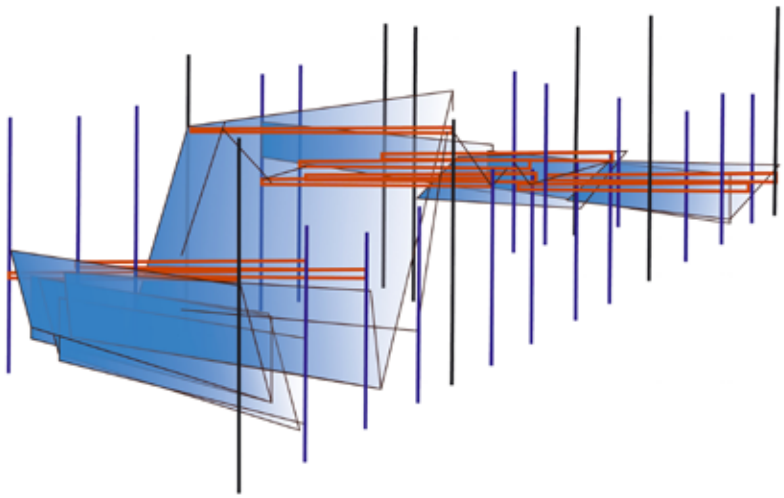
Risk management and civil protection

Taking into account the events and impacts mentioned above, it is clear that landslides represent a major challenge in terms of risk management, civil protection policy, urban planning, relocation and reconstruction, stabilisation and revitalisation. Italy makes considerable efforts in all these areas (ambitious restoration programmes for artworks damaged by natural disasters) with a considerable amount of technical and scientific know-how.

This kind of expertise is represented by experts such as Nicola Casagli, professor of Applied Geology at the Department of Earth Sciences of the University of Florence[21], and Claudio Margottini, Scientific and Technological Attaché at the Embassy of Italy in Egypt, and Professor at the UNESCO Chair in the University of Florence. Both have authored hundreds of publications and books about landslides.

In February 2019, I had a conversation with these two experts, from which I retained two important





The Price of Volatility,
Resonances III Datami
Gerlando Errore,
Structural engineering, 2019

Tiny Domingos,
draft, 2019

points: Nicola Casagli advocates for the establishment of a European landslide regulation, like the one already existing in Italy. Claudio Margottini underlined the importance of the relationship between landslide and cultural heritage, as well as the positive aspect that landslides can sometimes represent. In fact, the transformation of a given area by landslides can open up new uses of the landscape, such as agricultural projects. Therefore, this phenomenon could be reduced not merely to a negative factor.

In a more recent conversation, Mr. Margottini mentioned the relationship between geology and art (especially in Leonardo's works) and that the largest Landslide database in Europe located at the *ISPRA*[22] Institute in Rome. He also referred to his efforts to create a new scientific discipline: "cultural geology", which would combine engineering, conservation of cultural heritage, sustainability and the social reality of local populations. In other words: how can cultural heritage be protected with simple, ecological and economic resources that could also help the local populations. It is interesting to note the humanist dimension of this new discipline, which recalls the permeation of science into art during the Renaissance.

Landslides and cultural heritage

In South-European countries the tourism industry is a very important source of wealth. In contrast to Spain, which welcomes even more people (82 million), but mainly on its beaches and islands, tourism is spread throughout Italy. Outside the great tourist magnets, Venice, Florence and Rome, the various historic sites and typical villages attracted 23 million foreigners in 2018. These figures exclude the number of national tourists, as 80% of Italians spend their holidays at home. According to the World Tourism Organisation, an overall of 58 million foreign tourists visited Italy in 2018, attracted by its rich and dense cultural heritage.

Many of these picturesque historical sites were built on beautiful promontories, which at the time were chosen for geopolitical reasons, such as Pitigliano, Cività di Bagnoregio, Volterra and Craco. Unfortunately, these highs rest on more fragile geological layers that, over the passage of time, move due to worsening erosion and are threatened by landslides. The result: rockfalls, slope instabilities, flank collapses, debris flow. And it is here that Earth science specialists (such as the same Margottini, who has been monitoring Cività di Bagnoregio for a long time) deploy their activities, using their know-how, the historical data available and various sophisticated equipment, to stabilise flanks, to delay ongoing landslide processes, and to mitigate the already existing negative effects. It is an effort to prevent future occurrences, and preserve these very particular historical sites that constitute the soul of Italy.

Revitalisation and overload

Cività di Bagnoregio is an emblematic case of intervention and revitalisation. The advanced process of erosion and loss of inhabitants has led to a special programme for this picturesque town, involving the construction of a pedestrian bridge and the introduction of an entrance fee, in addition to concerted efforts to slow down the landslide process.

Outside these endangered historical sites, the geomatics and geotechnical teams are regularly at the service of cultural heritage conservation, namely through structural health monitoring and geotechnical inspections on heritage sites of high cultural value (churches, bridges and monuments). Such is the case of the *Pontasieve Bridge*, an ancient bridge over the river Sieve (close to Florence), commissioned in 1555 by the Medici family.[23]

V. Art and geology

Perspective, democracy and badlands

Perspective was first applied during the 15th century in Florence, following the rediscovery of Greek and Arab mathematics and geometry. It was pioneered by artists such as Masaccio (1401-1428), Paolo Uccello (1397-1475) and Piero della Francesca (1416-1492).[24]

For the first time, perspective allowed the unity of time, action and the notion of space in the pictorial domain. It was a revolution for art and science that would mark the birth of many disciplines, including, in the Western world, geology itself, in the 17th century in Tuscany. A pivotal moment in the history of western culture, which even extended to the Enlightenment.

This new window to the world represented not only a great scientific and technological step, solving "irresolvable" statics issues, such as Brunelleschi's dome in the Cathedral of Florence (1420-1436). It also provoked a great democratic advance as the broad public could understand this ground-breaking innovation. Even today, a layman can perfectly enjoy the three-dimensional illusion of perspective projected on a two-dimensional surface. Furthermore, the attention given to landscapes in painting stimulated the visualization of geology. Presently, these backgrounds are a precious source for the study of various geological typologies. The study of the past may bring important clues to the understanding of the present and the anticipation of the future. For example, Earth science experts use famous Renaissance masterpieces to reconstitute the geomorphological evolution of landscapes, such as Piero della Francesca's *Diptych of the Dukes* (1473-1475) for the Montefeltro region.

In the case of the San Leo rockfall[25], these detailed landscapes allow experts to discover the shape of this cliff before the historical landslides occurred.[26]

I would like to draw your attention here to the work of Rosetta Borchia and Olivia Nesci, self-proclaimed "landscape hunters", whose conclusions - published amongst others in *The invisible landscape*[27] – led the administration of the Montefeltro region to set up a Renaissance view circuit.[28] It allows the visitor to have access to the painter's presumed perspective and "to move within the work of art".[29]

I end this tour of Renaissance painting with Leonardo da Vinci (1452-1519), who took a keen interest in geology.[30] A fact clearly illustrated by his drawings and writings on geological phenomena and typologies. Leonardo's first dated work is a landscape drawing using the perspective: *Paesaggio con fiume* (5th August 1473).[31] This is the first time that a landscape was not treated as a backdrop but as a central theme of an artwork.

Another eternal object of research is the landscape of the *Mona Lisa*, which the authors claim to have identified as being from the same region. There are two other paintings by Leonardo that deserve to be cited for their link with geology: *The Virgin of the Rocks*, which exists in two versions (at the Musée du Louvre in Paris and at the National Gallery in London), and *The Annunciation* (Galleria degli Uffizi in Florence). The surreal lunar appearance of the eroded formations clearly visible in the background, known as *calanchi*, were a preferred motif of Leonardo.

Calanchi are translated in English as *badlands*: "Badlands are areas in arid regions that are cut by deep, narrow erosion channels. (...) The surface of the soil in badlands is characterised by slightly weathered rocks and open ground. The effects of water or wind quickly erode slate clays, claystones and loams, leading to the formation of typical surface forms. (...) A badlands area consists mainly of constantly widening gorges and valleys, between which sharp ridges remain."[32]

This type of terrain stimulated my interest when analysing the surroundings of Cività di Bagnoregio, which, along with Craco, Volterra and Canossa are both *calanchi* and landslide areas.

This project curiously interlinked many different themes.[33]

VI. panta rhei

> *All things are in flux; the flux is subject to a unifying measure or rational principle. This principle (logos, the hidden harmony behind all change) bound opposites together in a unified tension, which is like that of a lyre, where a stable harmonious sound emerges from the tension of the opposing forces that arise from the bow bound together by the string.*
> Heraclitus

I had the pleasure to visit Chiara Del Ventisette, researcher in Structural Geology, Geography, Geology, Remote Sensing and Analogue Modelling at the De-

The Price of Volatility,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view
Photo Tiny Domingos

partment of Earth Sciences, University of Florence. She was kind enough to show me the laboratory where landslide simulations are performed, using coloured sand layers and models. We discussed landslides, flank collapses and the study case of Vajont. Her expertise was invaluable for the realisation of a landslide simulation experiment that carried out at the JRC Ispra, called *Flank Collapse*.

At the time of our conversation, it had already become clear that the concept of *panta rhei* – everything flows – would be at the heart of this project. After all, everything is in motion on earth: water, soils, tectonic plates. Even the planet rotates on itself and around the sun and so on. The above-mentioned cases of landslides near historic sites underline the contrast between the need for stability, conservation of heritage and landscape, and the instability inherent to landslide kinetics, surface displacements, slope instability and geomorphologic evolution.

VII. Econometrics + geomatics = Landslide

Econometrics, the statistical metric for economics, can be regarded as one of the main innovations which turned twentieth century economics into an engineering, or tool-based science, in which each application of economic theory requires special shaping to circumstances, whether for scientific purposes or in the policy domain (see Morgan 2001). The development and use of statistical tools for economics emerged in the early part of the twentieth century and, by mid-century, problems had been defined, solutions approached and usable concepts developed, so that one could legitimately refer to a distinct body of knowledge embracing both theory and practice. After 1950 econometrics became a mature field and the dominant method of applied economics.

M.S. Morgan and D. Qin, 2001[37]

At the JRC Ispra, I met Luca Tiozzo Pezzoli[34] and Luca Barbaglia[35], two researchers of the Centre for Advanced Studies (CAS) project *Big Data and Forecasting Economic Developments.*

From the start, I tried to reflect on how this SciArt project could integrate an economic dimension that I find fundamental for the description of contemporary reality. In my artistic practice, the interest in economic statistics and data visualisation is evident.[36] My conversations with Luca Tiozzo Pezzoli proved to be very fruitful. And were supplemented with the arrival of Luca Barbaglia. With the participation of these two researchers, the *Landslide* project integrated an econometric aspect, enriching and extending its scope and leading to the design of new works mentioned below. I invite you to read the explanatory texts for their contribution.

There are numerous analogies between economy and geotechnics, such as the impact of their crises on humans or in the use of equal or very similar vocabulary. Collapse (of markets) recalls "flank collapse"; stability refers to the "European Financial Stability Facility" and "Stability Pact". Instability (of markets) resembles "slope instability". Securitisation recalls "slope stabilisation" and civil protection "risk management". *High frequency economy* resembles "high frequency earthquake".

In both fields, Big Data is used as a mechanism to improve stability and mitigate negative effects as well as a monitoring and prevention instrument. What these fields have in common is the aforementioned *panta rhei*, the idea that everything flows, everything is in motion. That instability can happen at any time and therefore needs to be taken into account.

Special focus: South of Europe

The South of Europe experienced great eras of social, scientific and economic development, making it the cradle of Western culture. It is known and appreciated worldwide for its unique cultural heritage, its climate, its gastronomy and hospitality.

During the Eurozone Debt Crisis (2011-2012) these countries assembled the most exposed populations and were called PIGS, which ingloriously stands for Portugal, Italy, Greece and Spain.

« Le diagramme ne fonctionne jamais pour représenter un monde préexistant, il produit un nouveau type de réalité, un nouveau modèle de vérité. Il fait l'histoire en défaisant les réalités et les significations précédentes. Il double l'histoire avec un devenir. »

"The diagram never works to represent a pre-existing world, it produes a new type of reality, a new model of truth. It makes history by undoing previous realities and meanings. It doubles the story with a future."

Gilles Deleuze, Foucault, Paris, Les Éditions de Minuit, 1986

These countries are also the most exposed to geo-hazards such as earthquakes, landslides, volcanic eruptions and tsunamis. This project focused on how these two risks coincide for all these countries.

Eurozone Debt Crisis as a seismic shake

The Eurozone Debt Crisis threatened the stability of the European currency and unsettled the economy of the whole continent – even endangering the future of the European Union. This had many similarities with a natural catastrophe, and can be seen as a major earthquake with serious consequences for the populations of these countries. All of a sudden, citizens had to face fast rising taxes, large wage cuts, loss of purchasing power, rising unemployment and housing loss. Governments had to cut budgets in key sectors such as health, education, transportations and culture.

Flank collapse

After finding the analogy between crisis and seismic events/landslide, the idea of conducting an innovative experiment arose. How could you trigger a landslide with data from the Eurozone Debt Crisis?

By translating these economic data into seismic data and then transferring it to the mono-axial table of the European Lab of Structural Assessment (ELSA, JRC) to trigger an earthquake and subsequent landslide. This scientific experiment received the title *Flank Collapse* because the crisis was seen by some as a concerted attack against the most vulnerable economies in the Eurozone (the "weakest flank").

The exchange of ideas continued as a debate on the visualisation of economic data. We created three-dimensional images with the MATLAB® program, to show the evolution of the Eurozone crisis in perspective, as if it were a mountain landscape with high peaks and hollow valleys. We analysed the graphs of the evolution of maturity bonds for each country over ten years. We then decided to create a chart, using the data from Portugal, Italy, Greece and Spain to show the figures for PIGS countries.

Unfortunately, Greece, which was at the heart of the storm, could not be considered in the end, due to a lack of data (it would be interesting to know why these data are not available). Looking at the graphs in which Greek data are available, we see that they "burst the scale", which made it difficult to read them together when mixed with data from other countries. Undoubtedly, a shortcoming. Nevertheless, it facilitated the joint visualisation of data from the other Southern European countries and their subsequent materialisation in a sculptural form. The imagination of the viewer will have to complete the sculpture with this non-available data.

Blurring the frontier between digital and analogue

Inspired by the "3D landscape" obtained in this new graphic - which resembled a large moving wave or a mountain landscape - I immediately thought of its phys-






Landslide
Resonances III Datami
Festival JRC Ispra
15 October-8 November 2019
Tiny Domingos,
Stills from *LANDSLIDE TV* [digital projection], 2019
[1.Gibellina, 2-3. Craco, 4. San Fratello,
5. San Leo, 6. Civita di Bagnoregio]

Landslide
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Tiny Domingos,
A still from the video piece
Flank Collapse, 2019

ical materialisation. *The Price of Volatility* was born: an outdoor sculpture with a 28-meter long sail boat fabric. An artistic interpretation underlining the analogy between financial and seismic stress, not as a mere visualisation of the data (although strongly inspired by it). The title, taken from a 2D chart, seemed to fit perfectly with the notion of constant flow and the (un)predictability of economic and seismic risks. The wind brought its own dynamics in this data landscape and changed its perception. The outdoor location and the choice of lightweight materials corresponded to the curators' directions. A challenge that met my concerns.

Other works blurring the frontier between digital and analogue:

- *Average Houses Price* based on a chart, created by the two researchers for this project. Showing property price developments from 2000 to 2018 in seven European countries (with naturally diverse flows). The housing price is a standard reference that allows checking the financial health of each country.

- *3 lines (Indicator of Systemic stress)* is based on a chart of the European Central Bank: *Composite indicator of systemic stress in euro area sovereign bond markets (Jan. 2004 - Apr. 2018)* showing the stabilisation of markets after the Euro crisis.

- *LANDSLIDE*: mirror table with a data landscape formed by sculptures related to data from European institutions and from landslide research.

In September 2019, I travelled to the island of Stromboli and accompanied Tullio Ricci, researcher at the National Institute of Geophysics and Volcanology (INGV, Italy) to Sciara del fuoco, the famous slope where one can observe the smoking stones regularly expelled by the volcano fall directly into the Tyrrhenian Sea. Based on INGV images, the video FLANK COLLAPSE tries to describe this millenarian process that impresses by its radical simplicity and beauty and invites to silence.

VIII. Datami

Datami is the place where the complementarity and increasing interpenetration of the digital and physical world becomes clear. Everything flows up and down in both dimensions. Big Data helps to understand of the complexity of the unstable territories we inhabit. Democratic action and the appropriation of the digital space allow resilience in times of rapid changes. As in geomatics and econometrics, the challenges are Monitor / Resist / Mitigate / Prevent.

This project defends the inviolability of independent artistic and scientific research and calls for a new digital revolution based on respect for human dignity and individual freedom. It also promotes a new digital humanism based on dialogue and curiosity and rejects defeatism and the erosion of democratic values, such as freedom of expression and the right to difference.

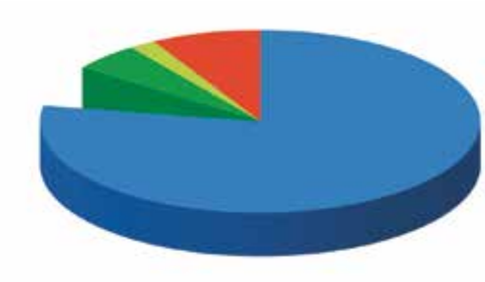
Landslide is a hospitable SciArt work, simultaneously plural and singular, that builds its own space/time and unfolds in multiple ways, creating bridges with a variety of epochs and disciplines and aiming at a new awareness beyond personal, cultural, professional and academic boundaries.

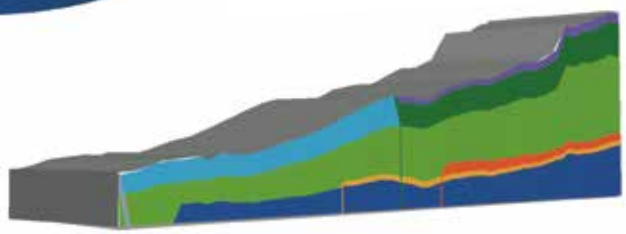
Datami is the ceramist's lathe where it is possible to shape the future with one's own hands.

Residential markets in Europe

Luca Barbaglia

In the aftermath of the 2008 financial crisis, the opacity of loan securitisation processes has been identified as one of the most relevant causes of the crisis. Loan securitisation allows banks to diversify their credit risk, obtain additional liquidity and provide easy access to credit. However, it may contribute to lengthening the intermediation chain, ultimately increasing both individual and systemic bank risks. The loss of credibility in such a financial instrument has caused a dramatic contraction in the European securitisation market since the onset of the financial crisis, thus contributing to a further slowdown of the





LANDSLIDE,
[data landscape on mirror table, projection]
Resonances III Datami
Festival JRC Ispra
15 October-8 November 2019
Installation views in Visitor's Centre,
Study of sculptures
Photos Tiny Domingos

European economy. The European Central Bank (ECB) reacted with a number of macro-prudential policies to monitor financial risk and prevent risk from becoming systemic. Among other programs, in 2010 the ECB launched the *Asset-Backed Securities (ABS) Loan-level initiative*, aimed at increasing the transparency of loan securitisation processes by providing loan-level standardised information about assets accepted as collateral in Eurosystem credit operations. Under this scheme, loan-level information is provided in a timely and standardised format, allowing the health of credit markets to be monitored in semi-real time across countries or financial institutions.

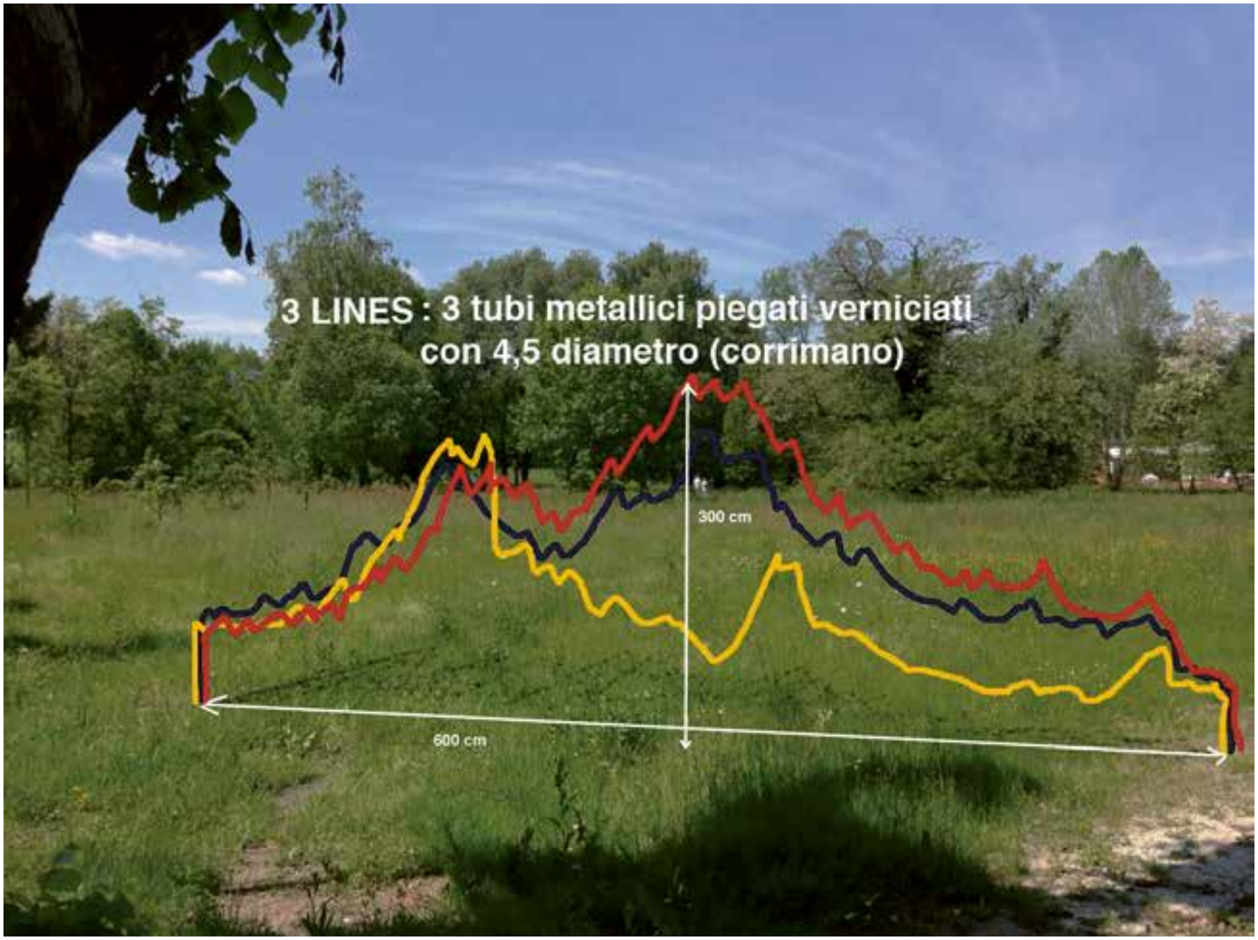
Looking at the evolution of the average price of the properties associated to the residential mortgages in the ABS program for Italy, Portugal and Spain, in a time span ranging from 2000 to the end of 2018, we see that these three countries were largely hit by the 2008-09 financial crisis and the subsequent 2011-13 European sovereign debt crisis. The reactions of the national economies have been different depending on the strengths and weakness of the local economic conditions. In Italy, there was a clear positive trend of residential property prices until 2008, followed by a slow and steady decrease in prices, indicating the difficult recovery of the Italian residential mortgage market. Spain followed a similar trend in the first years of our time sample. However, the price drop after the financial crisis is more pronounced and shorter than in Italy. Starting from 2015 residential prices in Spain started to grow again and drastically reduced the gap dividing them from their Italian counterparts. In Portugal, we observed a positive trend in the first part of our time sample, but its slope is smaller than for the two countries above. The Portuguese residential market suffered more the European sovereign debt crisis than the 2008-09 financial crisis, and showed positive increase in house prices only during the last year of our sample.

The Debt Crisis in Europe, 2008-2013

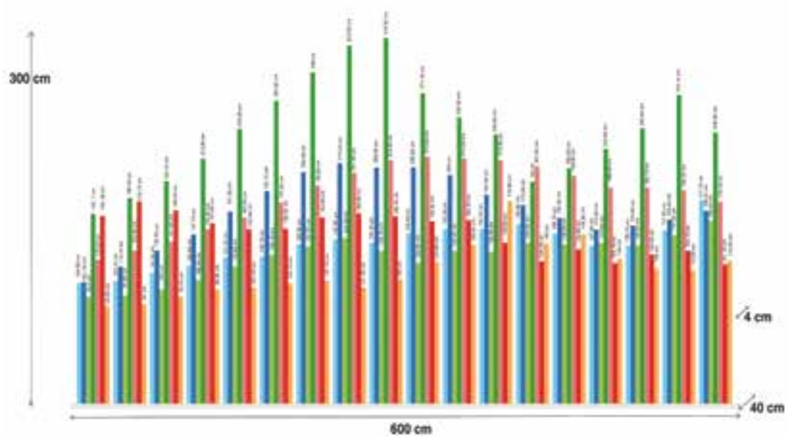
Luca Tiozzo Pezzoli

The 2008 financial crisis negatively hit financial markets worldwide. Many European banks, exposed to the US subprime mortgage market, suffered consistent losses, and decided to drastically reduce their lending and investments. Moreover, house prices drastically fell and banks capitals further decreased. A general economic decline and financial sector meltdown, known as the *Great Recession*, spread around Europe. In order to reduce systemic risk and preserve the overall financial stability, European states supported their banks through loans recapitalisation and bail out schemes but this considerably increased the amount of government debt. Financial investors were particularly concerned about Southern countries (such as Italy, Spain and Portugal) with poor economic prospects, low growth rates and pre-existing high level of public debt. Markets judged the size of their debts unsustainable in such a recessionary period and started to worry about the possibility of default of these countries. Investors started to demand higher interest rates for these risks and, in turn, it became more expensive for Southern economies to repay their debts. Those countries fell in a spiral during the 2011-2013, the so-called European debt crises.

In 2012, the intervention of the EU and the ECB helped those countries to lower their rates. A set of structural policies promoting fiscal consolidation improved the European financial stability, reducing market fears. In particular, the ECB started a monetary easing campaign in order to stimulate the distressed economies, while the EU provided recommendations on spending cuts and restrictive fiscal policies. However, such austerity measures should be implemented with caution. Too restrictive policies may not promote growth, increase unemployment, reduce tax revenues and produce citizens' resentment and political instability. This uncertainty would increase investor's anxiety and translate into a new increase in interest rates.



Tiny Domingos,
3 Lines [Indicator of Systemic stress], 2019
Draft for a public art sculpture based on a chart of the European Central Bank: "Composite indicator of systemic stress in euro area sovereign bond markets [Jan. 200-Apr. 2018]", showing the market stabilisation after the Euro crisis.
Square metal tube sculpture,
m 7 x 2,19 x 1



Tiny Domingos,
Average Houses Price, 2019
Draft for a public art sculpture based on a chart by Luca Tiozzo Pezzoli and Luca Barbaglia, Center of Advanced Studies, JRC.
Evolution during 2000-2017 in 7 countries of the EU.
Square metal tube sculpture,
m 6 x 3 x 1

"Chaque époque rêve la suivante"
Michelet: Avenir! Avenir!

Walter Benjamin, Das Passagen-Werk, erster Band,
Edition Suhrkamp, Frankfurt on the Main, 2015

"Each era dreams of the following one"
Michelet: Future! Future!
Walter Benjamin, 2015.

The yield curve 3D surface graph reported the evolution of average interest rates of three Southern European countries, namely, Italy, Portugal and Spain. The time span considered ranged from 2000 until 2019 and covered rates maturities from 2 to 9 years. We observed very low levels of interest rates before 2009. In this pre-crisis period, investors priced European bonds with very different underlined levels of national debt equally. However, the economic fragility of Southern economies appeared to be an important risk factor responsible of the strong interest rates increase during the European Debt Crisis (2011-12). From 2012 and afterwards, rates declined due to the structural policies implementation. However, a new increase of rates was present at the end of the sample. This is principally due to the political instability in Italy.

Notes

1. Consulted on lexico.com in August 2019
2. Consulted on merriam-webster.com in August 2019
3. Considered to be one of the first literary references to a landslide.
Source: Digital Dante https://digitaldante.columbia.edu/
4. Top 10 italian pop song from the 80's. Link: https://www.youtube.com/watch?v=0XW9XN_vDaA
5. Speaking about international cooperation. Source: https://www.welt.de › Politik › Deutschland
6. In original: "Le bruit d' un système qui va s'effrondrer" [título de um capítulo do livro de Pablo Servigne e Raphaël Stevens]
7. https://www.archeos.eu/collapsologie
8. Pablo Servigne e Raphaël Stevens, "Comment tout peut s'effondrer - Petit manuel de collapsologie à l'usage des générations présentes", Le Seuil, Paris 2015"
9. Diamond, Jared, Collapse: *How Societies Choose to Fail or Succeed,* Viking Press, New York, NY, 2005
10. See https://www.revue-ballast.fr/daniel-tanuro-collapsologie-toutes-les-derives-ideologiques-sont-possibles/.
11. Engélibert, Jean-Paul, *Fabuler la fin du monde, La puissance critique des fictions d'apocalypse,* Paris, La Découverte, 2019
12. The JRC has six sites in five EU countries [Brussels, Geel, Ispra, Karlsruhe, Petten, Seville]
13. Her special focus: olive oil, fish, wine grape and wheat, the very basis of the Mediterranean diet, which became the symbol for health & longevity bringing together values and traditions above religious, linguistic and national frontiers across the Mediterranean.
14. Such as Voltaire, Immanuel Kant, Wolfgang von Goethe, Walter Benjamin, and Theodor W. Adorno.
15. Geomatics. The branch of science that deals with the collection, analysis, and interpretation of data relating to the earth's surface. Origin: 1980s, from geography and informatics. Oxford Dictionary. Source: lexico.com [Consulted on August 2019]
16. M. Klose, "Landslide Databases as Tools for Integrated Assessment of Landslide Risk", *Springer Theses,* DOI 10.1007/978-3-319-20403-1_1 Cham: Springer International Publishing, Switzerland 2015
17. Intense or prolonged rainfall, earthquake shaking, volcanic eruptions, rapid snow melt, slope undercutting by rivers or sea waves, permafrost thawing [https://esdac.jrc.ec.europa.eu/themes/landslides]
18. Slope excavation and loading [e.g. road and buildings construction, open-pit mining and quarrying], land use changes [e.g. deforestation], rapid reservoir drawdown, irrigation, blasting vibrations, water leakage from utilities, etc, or by any combination of natural and/or man-induced processes. [https://esdac.jrc.ec.europa.eu/themes/landslides]
19. 10108_RAPPORTO_83_08_Landslide.pdf
20. Source:https://earth.esa.int/fringe03/proceedings/papers/11_stramon.pdf
21. Nicola Casagli is currently head of the Department of Civil Protection's Centre of Competence at the University of Florence, member of the Major Risks National Committee, as well as founder and Associate Chair of the UNESCO Chair on the Prevention and Sustainable Management of Geo-Hydrological Hazards at the University of Florence.
22. ISPRA stands for *Istituto Superiore per la Protezione e la Ricerca Ambientale,* the National Institute for Environmental Research and Protection, in Rome.
23. Scientific correspondent Francesco Mugnai took part in this project: https://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XLII-2-W11/895/2019/isprs-archives-XLII-2-W11-895-2019.pdf
24. See also Andrea Mantegna [1431-1506], Antonio Pollaiolo [1432-1498], Sandro Botticelli [1445-1510], Pietro Perugino [1450-1523], Giovanni Bellini [c. 1430-1516], Marco Palmezzano [c. 1459-1539] and Raphael [1483- 1520]
25. Description of geological features on the San Leo site:https://www.san-leo.it/en/territorio/geology.html
26. For more informations see Giardino Marco, Giovanni Mortara, Lisa Borgatti, Olivia Nesci, Cristiano Guerra, and Claudio Lucente Corrado, "Dynamic Geomorphology and Historical Iconography. Contributions to the Knowledge of Environmental Changes and Slope Instabilities in the Apennines and the Alps" in *"Engineering Geology for Society and Territory, Preservation of Cultural Heritage Volume 8"* edited by Giorgio Lollino, Daniele Giordan, Cristian Marunteanu, Basiles Christaras, Iwasaki Yoshinori, Claudio Margottini, Editors, 463-468, CHam, Springer, 2015.
27. Borchia, Rosetta and Olivia Nesci, "The invisible landscape. A fascinating hunt for the real landscapes of Piero della Francesca among the Montefeltro Hills", Ancona, l Lavoro Editoriale, 2012.
28. http://www.travelingintuscany.com/art/pierodellafrancesca/balconyofpierodellafrancesca.htm
29. St. Jerome and a donor, The Nativity, The Baptism of Christ and The Resurrection are other works by Piero Della Francesca whose landscapes these authors claim to have identified.
30. See "A rockfall in a mountainous landscape", c. 1512-18, black chalk on paper, on display at the Queen's Gallery in London, showing an expressive collapse of a rock wall.
31. Gabinetto dei Disegni e delle Stampe, Galleria degli Uffizi, Florence
32. https://de.wikipedia.org/wiki/Badlands [translation by the author of these lines]
33. For more information on the link between art and geology, please see the article of Gian Battista Vai "The Scientific Revolution and Nicolas Steno's Twofold Conversion", in *Memoir of the Geological Society of America,* edited by Gary D. Rosenberg, 203 [2009]: 187-208.
34. Luca Tiozzo-Pezzoli was a researcher and professor at the University of Paris 1 Panthéon-Sorbonne, and a researcher at Banque de France and CEPII. He has a PhD in Management Sciences [with specialisation in Financial Econometrics] from Paris Dauphine University
35. Luca Barbaglia worked as a data science consultant until 2018. He holds a PhD in Applied Economics at KU Leuven [Belgium] and his main interests are time series analysis, large data sets and commodity markets.
36. For example.: PROJECTEDSPACE: RANKINGS 1 Digital print on fabric [5 x 3 m]. FAULT LINE Encontros da Imagem 2017, Monastery São Francisco de Real, Braga, Portugal
37. M.S. Morgan and D. Qin, "Econometrics, History of", in *International Encyclopedia of the Social & Behavioral Sciences,* 2001.

The Sound of Waves

Artist
Daniel Nicolae Djamo

Scientists
Pascal Colpo
Daniela Ghio
Douglas Gilliland
Raimondo Giuliani
Francesco Mugnai
Michele Vespe

Collaborator
Jorge Figueiredo Morgado

The Sound of Waves,
SciArt Datami project, 2019
Interactive Installation
Ferrofluid and electromagnetic grid

The Sound of Waves,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view [detail]
Photo Daniel Nicolae Djamo

The Sound of Waves

Daniel Nicolae Djamo

The European Parliament has identified 4 main pillars for rebuilding its asylum and migration policies: reducing the incentives for irregular migration by addressing its root causes, improving returns and dismantling smuggling and trafficking networks; saving lives and securing the external borders; establishing a strong EU asylum policy, and providing more legal pathways for asylum-seekers and more efficient legal channels for regular migrants.

The Sound of Waves is a collaborative research project which curdles into experimental art, uniting artist and scientists.

It focuses on migratory trajectories from outside the EU towards the EU, and from poor EU countries towards the more developed and stable EU territories. The work translates data on migratory waves, made available by JRC demographers working on immigration, into a very concrete, material medium, even though the form remains rooted in poetry. It is limited to the ten-year period going from 2008 to the end of 2017, a time frame that proved to be crucial for a host of Eastern European work migrants. Romania and Bulgaria joined the European Union on 1st December 2007. After that date, Romanians left in masses towards Spain (reaching numbers of around 700.000 in population), Italy (1.1 million), France (around 200.000), the United Kingdom (around 390.000), and Germany (around 450.000). Entire areas of Romania became progressively depopulated and the country was faced with a workforce crisis. Doctors, engineers, architects, IT experts and economists left a big gap in Romania's pool of experts. This was years before the Syrian Crisis threw a great number of Syrian refugees onto European shores.

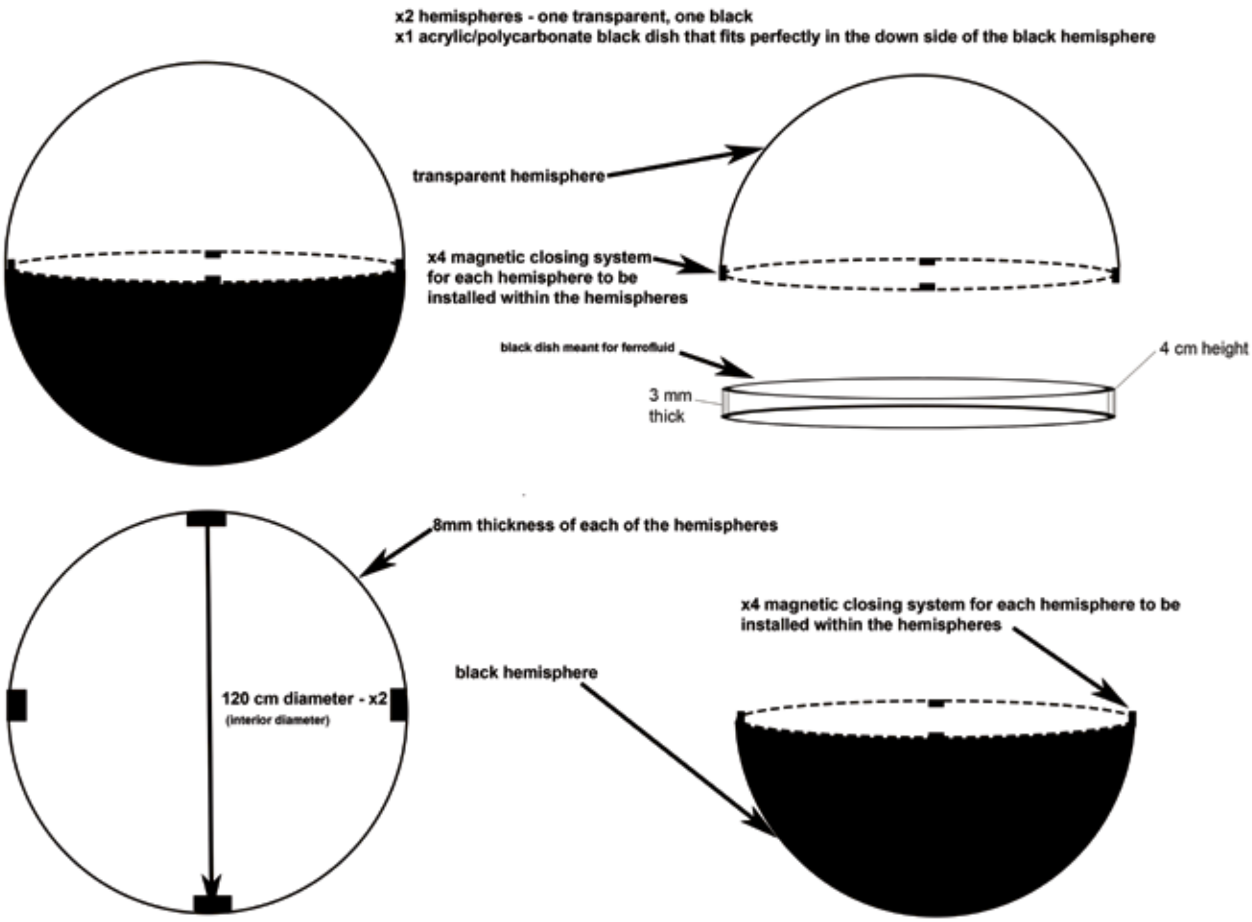
The research team devised a novel solution combining various JRC researches and competences. In particular, the expertise of JRC scientists and technicians of the innovative sensors "MELISSA" lab was essential. Their ferro-fluid installation with a diameter of 90 x 90 x 90 cm shows the different waves faced by the EU in an innovative set-up. The dark ferro-fluid is brought to "life" with the help of linear electromagnets, showing the successive waves of transition literally as waves transiting from one place to another. The migratory waves thus become literal waves of transition from one space to another, in a liquid form.

The waves are coordinated from a control grid. Each wave approximates in size and height the migratory paths from the 'not-so-developed' EU or non-EU to the developed EU. We used Eurostat data for the project. 66.7% of the input data is based on numbers of foreigners seeking asylum within the EU and 33.3% of the data was that of work migrants within the EU countries. Each wave represents one month of migratory data, starting 1st January 2008 until 31st December 2017. Thus, each year has twelve waves, so that the 10 years will be represented by 120 wave frequencies. In this manner, the installation faces us with 120 waves of change.

The ferro-fluid reaches a determined height, according to the electromagnetic strength given by the electromagnets. The strength also determines the distance between the electromagnet and the surface of the liquid, all in a predetermined sequence governed by an Arduino device[1]. Each wave frequency lasts 6 seconds, so that the total duration of the entire set of sequences arrives at 12 minutes.

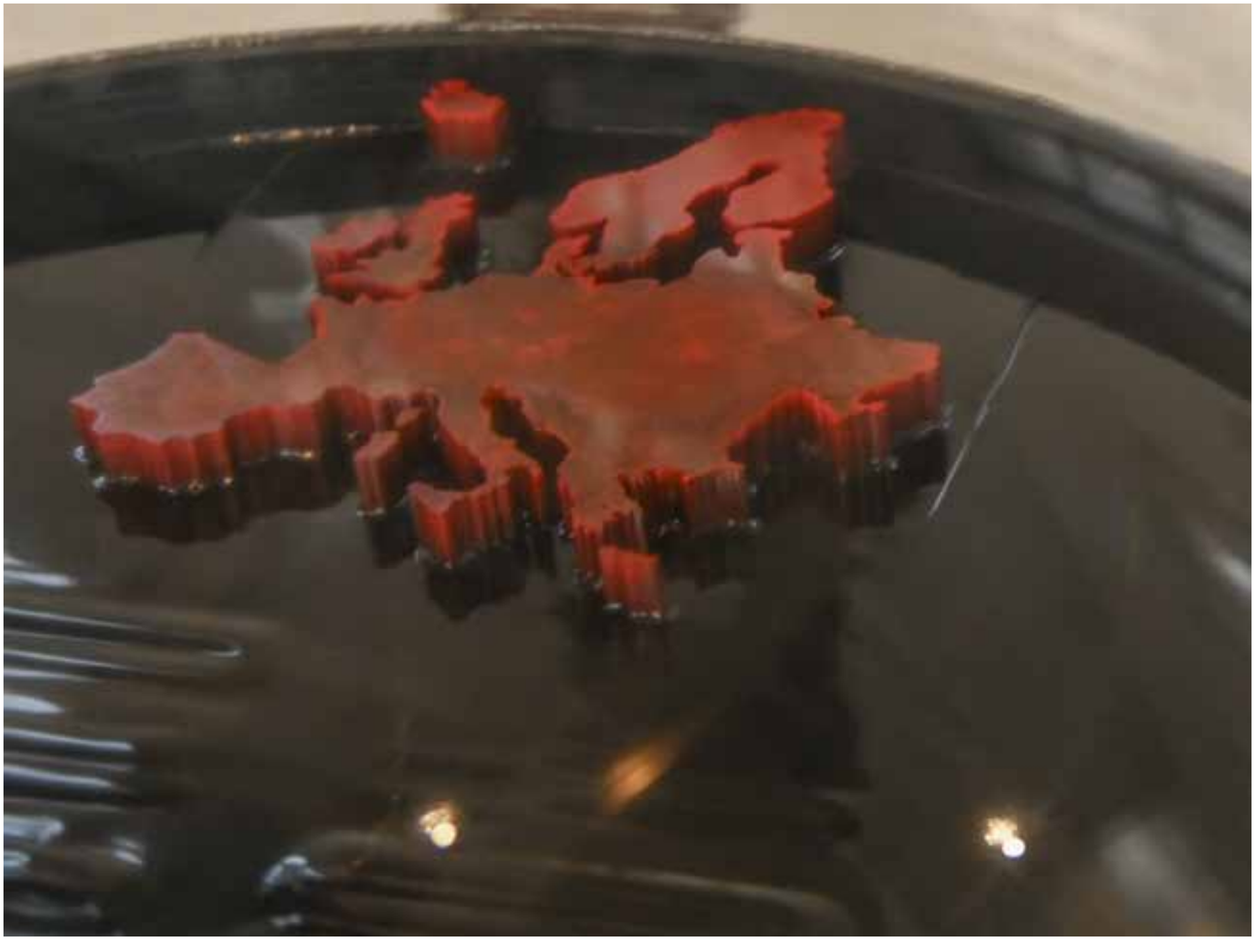
As it is difficult to influence the amplitude, the different figures are expressed by a different frequency. The smaller the frequency, the faster the waves appear to move, indicating a high migration flow. Each frequency is calculated between a maximum delay of 15 milliseconds and a minimum delay of 230 milliseconds. The Eurostat data was provided by Daniela Ghio and Michele Vespe, and it was converted through a mathematical calculation, setting the overall minimal migration flow to 230 milliseconds (for lower figures) and the maximum to 15 milliseconds (for higher figures of migration).

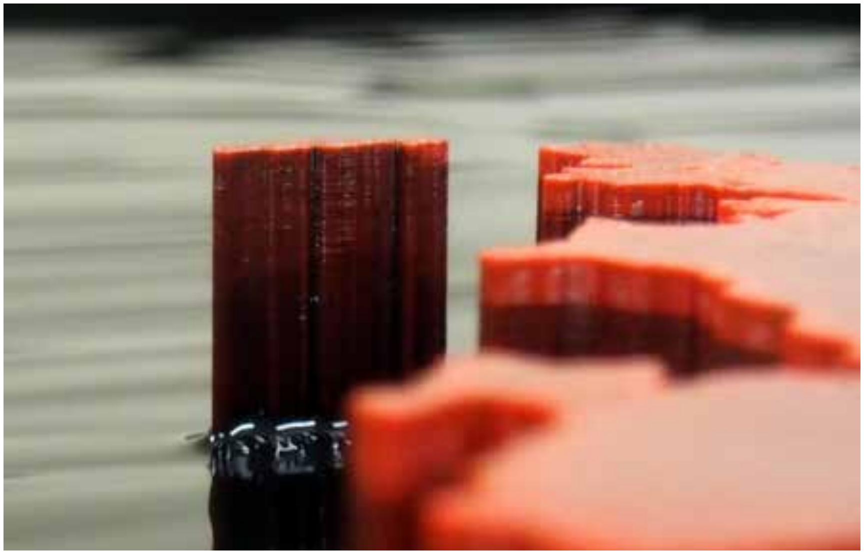
The larger the delay, the slower the waves appear to be moving. The smaller the delay, the harder is to



The Sound of Waves,
Resonances III Datami
Daniel Nicolae Djamo,
materials, 2019

The Sound of Waves,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view
Photo Daniel Nicolae Djamo





The Sound of Waves,
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 -19 January 2020
Installation view [detail]
Photo Riccardo Pareggiani

The Sound of Waves,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view [detail]
Photo Daniel Nicolae Djamo

spot the waves moving, since the human eye is incapable of spotting the differences.

Our endeavour hopes to reflect upon the different pigments which blend together make up a society. Since its formation, societies have greatly suffered from primary fears, deeply embedded in all of us: the fear of the unknown. Reluctance towards being in unusual spaces, up to the refusal of having „strangers" in our homes or the obvious impossibility of accurately observing the world of „the other" through his eyes.

In *La communauté inavouable* (1983), Maurice Blanchot poses the question: what form of community is still possible in this society? A society that balances between the needs of the individual and that of any community incapable of creating a communion that at the same time can respect individual freedom and satisfy the individual's need of the other? How can we create a community that can function as a solid body while respecting its individuals? However, Blanchot does not really give an answer to his own question.

Hobbes' *Leviathan* (1651) discusses another form of adaptation, debating the social contract by which people give up some of their rights to sovereign authorities, leaving the wilderness of nature where the only valid phrase is "homo homini lupus" (man is a wolf to man).

Kant's 1797 work *Metaphysics of Morals* is divided into *The Doctrine of Right* and *The Doctrine of Virtue*. In The Doctrine of Right, Kant uses the term 'rights' with a different meaning from contemporary talk concerning "our [their] own right[s]." Towards the end of the work the philosopher concludes by saying that "war has no meaning, both between individuals and between states, whereas war is not the way that one should hope to acquire rights." We urge to interpret Kant as a break from daily life, accepting the state of things, rather as a transcendence to another law, which finds itself independent of a socio-temporal context.

Our project aims at taking into consideration the general emptiness resulting from migration: of the liveable space that is left behind, the emptiness of the individual's own life (thinking about the kids in countries like Bulgaria that have to be raised by grandparents, becoming orphans on a psychological level) and the cultural loss, that is wasted if there are no people to pass on cultural values to, in an inhabited space.

The Sound of Waves thus offers a poetical observation of migratory waves and questions territorial boundaries.

Notes

1. Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing. – From the Arduino website, at https://docs.arduino.cc/learn/starting-guide/whats-arduino

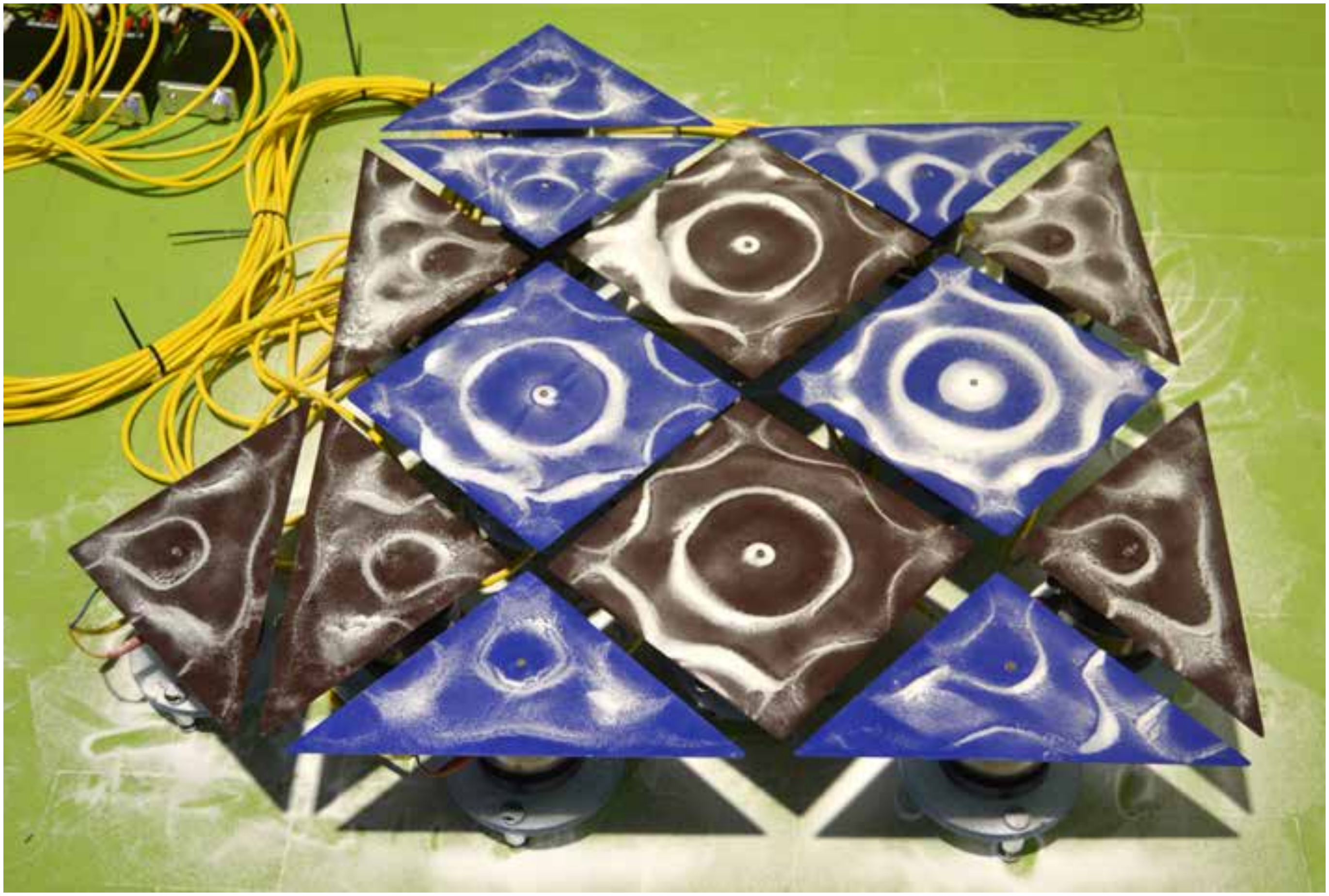
The Sound of Waves,
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 – 19 January 2020
Installation view
Photos Daniel Nicolae Djamo

‘Life is Motion’

Artist
Nicolas Strappini

Scientist
Daniel Tirelli

'Life is Motion',
SciArt Datami project, 2019
Installation, anodised metal plates.



'Life is Motion',
the sound figures are
visualised on the anodised
metal plates
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view
Photo Nicolas Strappini

'Life is Motion' Installation

Nicolas Strappini

We invite audiences to collaborate with the artist and scientist by recreating Ernst Chladni's resonance experiments. Chladni ran a violin bow along the edge of a plate covered with flour and saw patterns emerge.

The anodised steel plates used for this installation are arranged so that they run parallel to the edges and the diagonals. The lines intersect to produce a check or chess-board pattern. The chess-board design is used so that it accentuates the symmetry embedded in the way instruments produce sound. The plates with the sound figures visualised are reminiscent of Pugin tiles created by the Victorian architect Augustus Pugin that are used in the Houses of Parliament of the United Kingdom. This familiar motif also references the "Reunion" (1968) chess match between Duchamp and Cage and how the music was produced using photoelectric cells under the board (Fetterman, 2012). This installation uses sound in a similar way to the artistically important match and alludes to Duchamp's *Playful Physics* and some of Cage's inventive later sound work.

Audiences are invited to drop salt onto the plates in order to replicate Chladni's original process in which he played a metal plate with a violin bow, creating patterns in powder strewn on the plate. The material is thrown into rapid movement by the vibration and is finally arranged into a symmetrical design. When resonating, the plate or membrane is divided into regions that vibrate in opposite directions, bounded by lines where no vibration occurs, known as nodal lines. The installation uses two different shapes to demonstrate that the nodal points on surfaces change depending on the shape of the plate. Visitors also have the opportunity to visualise their voice made visible in eight different pure frequencies using a switch bank.

The installation features fourteen modal exciters on levelling bases. Anodised and spray-painted metal plates with a cellulose finish are positioned on top. The installation also features a manual Chladni plate that will feature the archetypal sound forms. Violin bows can be used against the Chladni plates. Rosin is used on the bow as it provides the bow hair with the necessary friction to produce a sound .

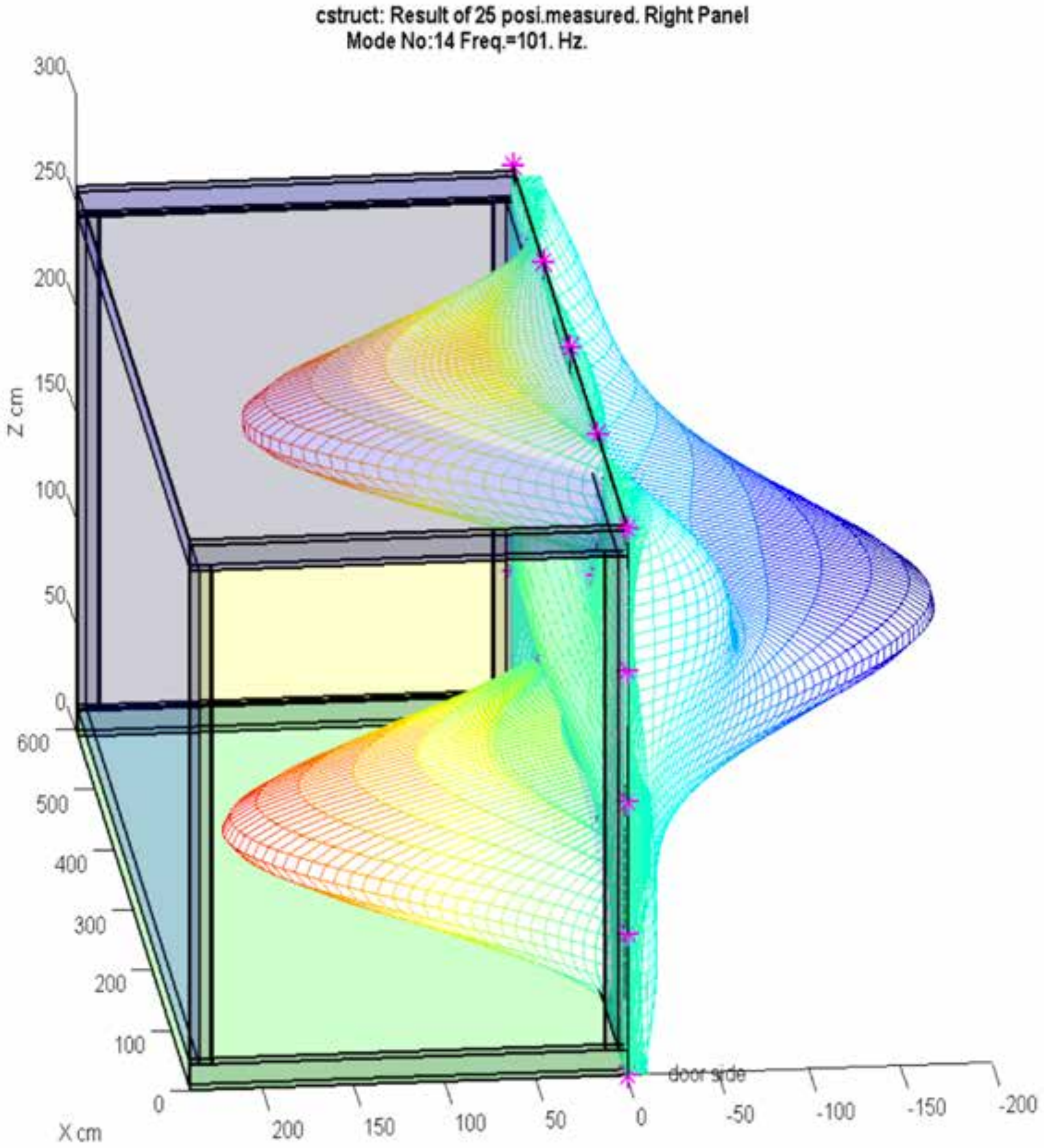
The performative element of the installation is also important, bringing to mind Enlightenment public lectures that demonstrated scientific principles to the general public. In the late 18th Century, Chladni began travelling around Europe demonstrating his musical curiosities. The main attraction was this novel technique that exposed the various modes of vibration of a rigid surface.

The current installation draws on this rich history while adding modern elements such as using loudspeakers and arranging the plates to accentuate the patterning. It also is one of the first public Chladni installations to use plates with varying colours and more than one shape and that offers participants the ability to visualise their own voices.

The science behind and the process

The JRC, in particular the European Laboratory for Structural Assessment, researches the safety of structures against earthquakes or dangerous dynamic events. Most of the experimental data are processed using the Fourier transform The Fourier transform separates and represents parts of a sound wave.

The importance of this aspect of data processing allowed the artist and scientist to meld their research. The artist's doctoral research investigates natural patterning using physical science phenomena and the engineer works on mathematical solutions and data processing. Chladni plates, which are the representation of mode shapes, relate to the processing of some of the European Laboratory for Structural Assessment (ELSA) experiments. A mode of vibration is just the way that something vibrates. When a xylophone is struck in the middle bar and is set to vibration, the bar is supported at two points towards the ends. The simplest mode of vibration is this: when the middle of the bar goes up, the ends of the bar go



Daniel Tirelli's research: an example of an experimental mode of vibration. This is a typical "chromosome" of all the possible motions of a panel being impacted by a hammer. This is the result of processing with the Fourier transform using about 1.5 million experimental data points. This relates to the Chladni experiment because both visualise the modes of vibration of a plate down. When the middle goes down, the ends go up. The two points that do not move are called nodes. The node has no motion.

Chladni plates can be described as the "artistic" representation (by sound and pattern) of mathematical solutions representing mode shapes. Chladni plates are usually small structures which, when excited by an impact or placed on a shaking table, simultaneously oscillate and emit sounds. Each individual plate, when shaken, has its own response in terms of the type of oscillation and the sound emitted. These responses are characterised by their frequency values and the type of shapes that are visualised using different vibration modes. These responses are the *identity* of the plates. They could suitably be compared to human genome data – invisible without some sort of microscopic examination. Structures such as buildings, bridges, or monuments are shaken by earthquakes or blown by the wind and move at their own frequency and with their own mode shapes, which could be called the *genome of the motion* of the particular structure.

To see this *identity* card from the experimental data, the microscope that is used is the Fourier transform. An example of these particular motions is shown in the pictures below for different structures tested at ELSA. Due to the velocity of the different motions and their superpositions it is impossible to observe each mode with the naked eye. When data are processed with the Fourier transform, we can see the fundamental types of possible motions of the structure and measure their frequencies. Chladni plates are therefore a way to perceive the powerful tool of data processing that constitutes the Fourier transform.

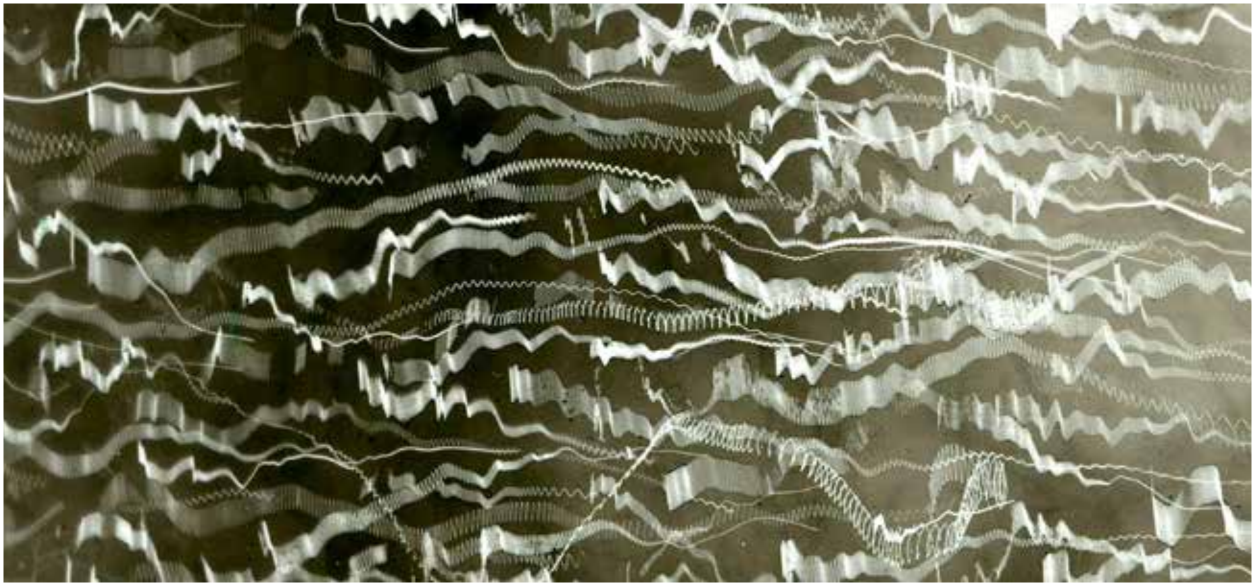
A human example of motion and Fourier representation is the pulsation of the heart. This could be seen as a datafication of human life. When the vibration frequencies become irregular, the health of the person becomes uncertain. The vibration frequencies can be represented by a dance of our cardiac muscles - the *mode shapes of the heart*. This analogy is further illustrated below. All these examples end up as data that represent "chromosomes of life" if we consider that "life is motion".

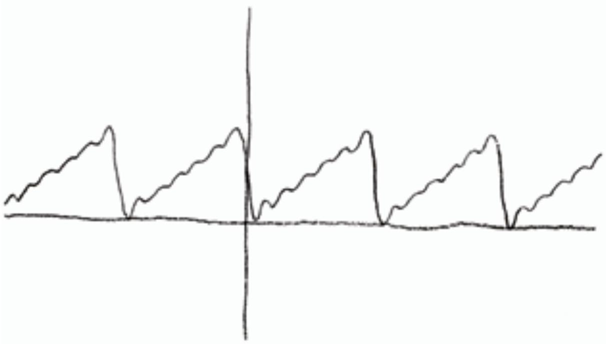
History of Chladni figures

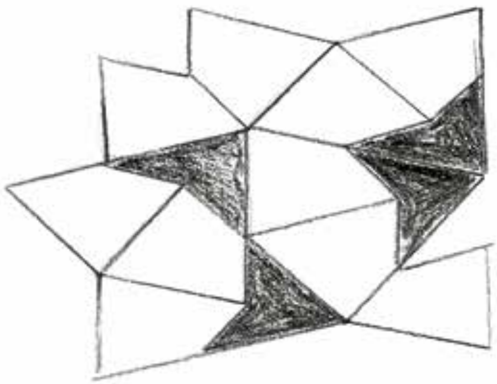
The concentric rings that form on the surface of the water used as a visual illustration for the movement of sound eventually gave way to Chladni's sound figures. Before Chladni documented resonance, similar phenomena had been noted for many centuries. The origin of human-assisted cymatics had been traced back to at least 1000 years to African tribes who used the tight skin of drums scattered with seeds as a form of divination. Da Vinci also documented experiments in his notebook that seem to correspond with our modern understanding of modal phenomena – after he set a table to vibration by hitting it, the dust formed along the nodal points of the object. He describes geometry and points of axis. "I say that when a table is struck in different places the dust that is upon it is reduced to various shapes of mounds and tiny hillocks." (Da Vinci and Curdy, 1945).

This insight is said to be unlocked by interdisciplinary discourse - the Renaissance polymath designed musical instruments and was also an accomplished practitioner. Chladni himself invented the *euphon* that "consists of forty-one immoveable parallel cylinders of glass of equal length and thickness. Its construction, tone, and the method of playing it, are totally different from those of the harmonica." (Alexander, 1798). The English natural philosopher Robert Hooke also documented similar patterning but it is not known if he had access to Da Vinci's writings. The performative element became both an important element to the dissemination of ideas, but it was also somewhat discouraged because the spectacle of pure amusement supposedly detracted from the necessity of practical instruction.

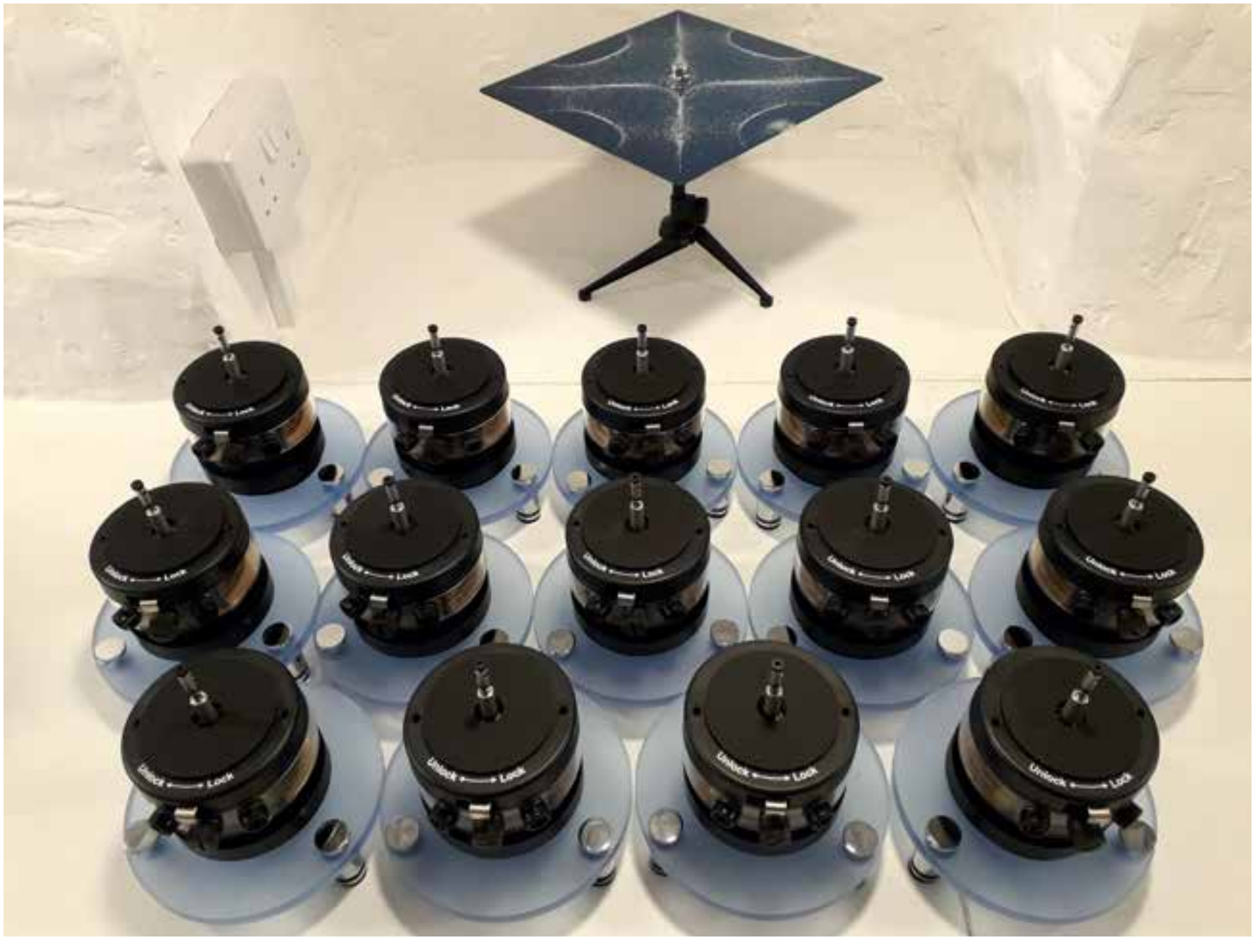
At this time of scientific experimentation, there was a push to *make the whole inner mechanism visible* (Brain and Cohen, 2007). Accordingly, in 1801, The Danish physicist Hans Christian Ørsted became interested in Chladni figures when he discovered he could use them as an example that their beauty is not random but is in harmony with the laws of physics. After Chladni had travelled the courts of Europe,







'Life is Motion',
Resonances III Datami
Nicolas Strappini*,*
studies: Fourier
transform*,* Tuning Fork*,*
2019



'Life is Motion',
Resonances III Datami
Nicolas Strappini*,*
studies: an unfinished part of the exhibition: modal exciters and a Chladni plate with an archetypal sound figure*,* 2019

Ørsted wanted to make physics more accessible to the masses. These demonstrations are a continuation of the tradition of physical science demonstration and also of the work of the natural philosophers. They also reference the Enlightenment principles of physical image-making and the spectacular public lectures and demonstrations.

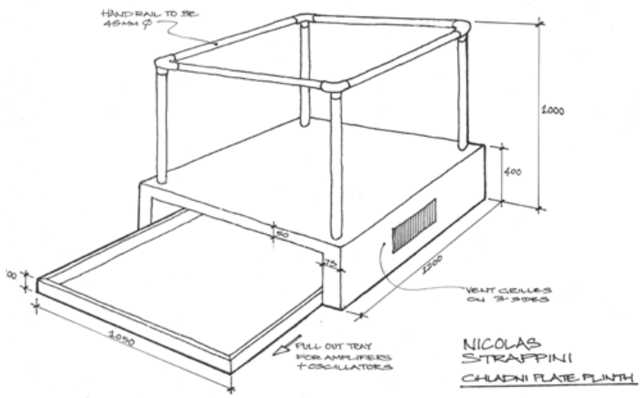
In reference to the previous mention of Fourier representation and the pulsation of the heart, the Scottish biologist D'Arcy Wentworth Thompson mentioned the connection between Chladni patterns and heart valves in his seminal *On Growth and Form* (1917).

Chladni's experiments are compared to Plateau bubbles . Thompson observed the way fluid collects at the corner of where bubbles meet, and he relates this to the way the sand (or club moss) forms on the nodal points of the Chladni plates. "Our bourrelet is analogous to the accumulation of sand seen where two nodal lines cross in a Chladni figure" (Thompson, 1917). His analogy was between the *corpora Arantii* of the human heart and Chladni figures. D'Arcy Wentworth Thompson's concern was to interrogate why living things and physical phenomena take the form they do.

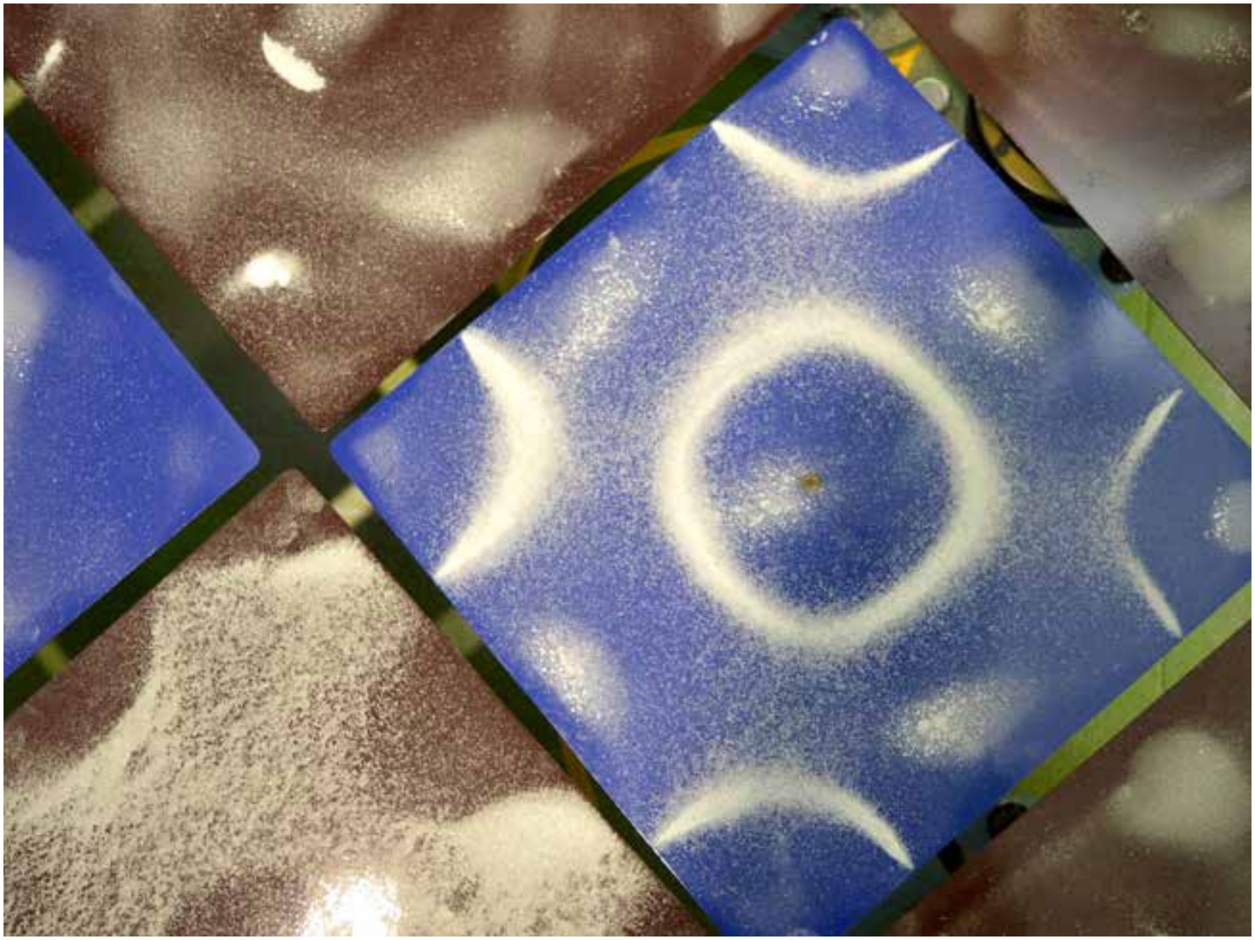
Chladni figures have inspired philosophical, scientific and artistic interest for thousands of years. These primordial glyphs have even been used in architecture for a 15th century chapel – the Rosslyn Chapel in Scotland. The geometry has been described as "the inscriptions [are] the originals for written language itself… every one of our spoken words is a secret song, for music from within continuously accompanies it" (Pesic, 2014).

Martin Kemp wrote about Sir Charles Wheatstone in *Nature*. He described how certain physical science phenomena or "philosophical toys" could be used to describe the fundamental laws of physics. Wheatstone invented the wave machine that is used to demonstrate the properties of waves. "The paths of the oscillating mirrors, traced by the persistent impressions of the reflected light, created beautiful and surprising patterns, comparable to Chladni's figures produced by sand on vibrating plates" (Kemp, 2000). This aspect of the physical science toy mobilised for the purpose of art has been seen in the work of Duchamp.

Nietzsche references Ernst Chladni in his *On Truth and Lie in an Extra-Moral Sense* (1873). The sound figures were seen as some sort of direct visualisation of nature that was undeciphered. However, this was at odds with Nietzsche's position – "for him, nature contains no inherent meaning, no rational order, and no divine teleology. The 'book of nature' was at best an anthropomorphic projection, and at worst a theological dogma" (Lyndon, 2016). There was a tendency to view these visual patterns in a doctrinal manner, but it is more practical to use the imagery for its inbuilt cultural cachet rather than taking it as evidence for some sort of divine *disegno*.



Pictures on this page
and on the next page:
'Life is Motion',
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view and detail
Photos Nicolas Strappini



Aesthetic Strategies in the Wasteocene

Yvonne Volkart

Aesthetic Strategies in the Wasteocene*

*[preprint for the Datami Book, 2019]
Forthcoming in: Aldouby, Hava [ed.]: Shifting Interfaces.
Presence and Relationality in New Media Arts of the Early 21st Century.
Leuven University Press Leuven [peer reviewed].

Intimacy will be the new code word. There will be no "away" towards which we can throw anything.... It's like the story of Anansi and the Tar Baby: the harder he tries to pull away, the more he finds himself stuck[1]. The indeterminacy of waste draws our attention to the imprescriptibility of ethical responsibility to future generations and environmental sustainability.... To paraphrase Barad, it matters how waste comes to matter[2].

You access a website that displays one sentence against a white background: "GOOGLE.COM EMITTED 1020.89 KG OF CO2 SINCE YOU OPENED THIS PAGE." While everything else on the screen stands still, the number rapidly increases: from 3244.35, to 3766.07, to 26035.67. You can hardly follow, let alone pronounce the numbers. The clock — your clock — is ticking.

I have been describing Joana Moll's real-time, Internet-based installation *CO2GLE* (2014). One click on the webpage sets off a CO2 counter, indicating that Google emits about 500 kilograms of CO2 every second due to users accessing the company's website from around the globe. *CO2GLE*'s "in-formational" aesthetic gives the impression that everything is under control: technologies count, measure, and track fluid atmospheric molecules, translating them into scalable and tradable digits. But you know better: there is no control, and you do not understand what these numbers really mean. Nonetheless, you are part of this multiplying force, this indeterminacy. You are part of this normalised, machinic CO2 output. You are a co-emitter of enormous abstractions, gigantic amounts of waste, because you are online, and use Google. You are entangled in this activity, participating in it, along with unfamiliar machines and people. And you understand one shocking thing: that uncanny things are going on behind the reassuring screen, with its minimal, black-and-white display. There are a multiplicity of beings out there, which you never, ever, fully understood. All the while, your clock is ticking.

CO2GLE raises my paper's basic question: What is the material impact of digital technology? Although my primary concern is with problems of waste posed by digital technology, particularly by the smartphone, I begin with Moll's insistence on the more general materialities of communications through the Internet:

"Almost nobody recalls that the Internet is made up of interconnected physical infrastructures which consume natural resources. How can such an evident fact

become so blurred in the social imagination?"[3] Both Moll's (rhetorical) question and CO2GLE, her ostensibly immaterial installation, lead to the heart a crucial problem with which we are confronted today: that matter does not matter in techno-capitalist times. Raw materials; human and animal bodies; plants and labour are constantly depleted, devaluated, and turned into waste. This process of wasting has a long history: colonialism, industrialisation, and digitalisation are its different faces[4]. They are each rooted in a belief in the abundance of resources and the assumption that increased technological skill will master the nature cultures. Subsequently, our cybernetic conceptions of information have come to disavow the material impact of technology, and are based instead on the idea of immateriality[5]. But times change, and while waste, people, and mobility ramify, raw materials and fertile soils decrease. This is how "waste" became material "information"[6]: waste tells us that information is (corpo)real. And it tells us not only that the endless devaluation of life continues in times of "immateriality", but that it is precisely digitalisation and its exploding need for resources that has accelerated this devaluation. Scarcely anybody thinks about the fact that an "immaterial" digital package — a simple message spoken into my smartphone — must circle around the planet before reaching my child chatting downstairs[7]. Put another way: CO2 emissions, electronic waste, the loss of biodiversity, and other forms of waste have all drastically increased over the last 25 years, corresponding exactly with the advent of the network society. Adding to CO2GLE, we can point to how language-based AI-networks and Amazon have become monstrous emitters of CO2. Welcome to the Wasteocene[8].

This paper begins from the premise that we live in times of waste. Waste haunts us: we settle in waste, we have to live with waste, not against it. In confronting the displaced and working through the abject, eco-aesthetic practices may provide a productive basis for thinking through the problematic of contemporary waste. Diverse practices and progressive strategies have been developed, especially in transmedia and research-based arts. These span the tracking trash, including waste from the extraction of raw materials; circuit bending; hardware hacking; practices of accumulating or co-composing electronic-waste; computer gaming; resurfacing "deleted" data; as well as work with dismantlers in their workshops.

Drawing on my collaborative research on the routes and transformations of the smartphone and its wastes[9], as well as on theories of new materialism[10 11] and media ecology[12 13] this paper analyses three contemporary new media projects, each of which provides a different perspective on electronic waste. It asks where and how their aesthetic media strategies open up transversal potential. Art is approached as a field of both symbolic expression and material articulation. It is an "interface" that can "shift" the normalised view of things, introduce difference, and thus open up other possibilities for action. *Shifting Interfaces*: the title of this collection might well describe the role of art, thus conceived. In approaching art in this way, I do not mean to overestimate its function, and recognise how aesthetic processes and relations have to be continuously restaged. Still, this notion of art allows us to grasp waste as a paradoxical figure, a boundary shifter, a disruptive force, and alien matter. Waste "is" something, or rather performs something that might become a promise: a promise of monsters[14]. As such, waste is always already alien and alienated. I claim that the potential of waste aesthetics lies in the calculated way it stages this foreignness of things, in all their incalculable foreignness. And it is this foreignness of the aesthetic — this unfamiliar perception — that gives rise to a surplus, an aesthetic excess, a transversal becoming.

Waste Always Wastes Anew

In German, garbage is called *Abfall*, meaning matter that has fallen away: it is the "fallen-away", the fallen-down, the abject. In life cycles, something always falls away, becomes useless, haunts order and culture. Mary Douglas has defined dirt as "matter out of place"[15] Bertolt Brecht spoke of dirt as "matter at the wrong place". These definitions of waste as abject, displaced matter — the down- or up-cycled plane in which the ontology of garbage is always situated — both depend on perspective. In a workshop I co-organised, the German historian Bernd-Stefan Grewe said that "Waste is matter that is too much mixed."[16] It is matter that you can no longer separate into its valuable and valueless components, at least not in a way that provides new economic resources. Mixing entails depreciation: what is mixed is unspecific, therefore tends towards worthlessness. With waste, everything becomes similar. Gray-brown indifference. Waste, therefore, is also monstrous, alien, feminine, queer[17 18 19].

In the end, waste is matter that does not go away; there is always something left over, a remainder, based on the physical law that something cannot turn into nothing. Waste disposal or cleaning generally means transforming waste into smaller pieces and transferring it to another place. Per definition, garbage cannot be dispelled without leaving traces, despite our hopes when we invent clinical terms like "recyclable" and "waste management", or technical "solutions" like geoengineering and the like. On the contrary, waste, garbage, rubbish, or "the fallen-away" does not resolve itself, but only wastes anew: every "fallen-away" generates a new "fallen-away", another useless leftover that might be harmful. By definition, waste is endless transformation: it is in movement, process, an endless state of becoming (something else). It is, as Armiero has said, not an "object", but a relation: a "wasting" "based on consuming and 'othering'", in his geopolitical gloss. Waste, Myra Hird suggests, "is anything but static and submissive: waste flows and mobilises relations"[20]. When a small device like a smartphone has been recycled, even with state-of-the-art-technology, there is always something left: after the device has been dismantled and shredded, various granulates remain; slag and ashes containing toxic particles survive the smelting of its gold, silver, and palladium; while the slag left by battery recycling contains other particles. They all are "sleeping" and might be mobilised and becoming toxic at any time through water or acid rain[21]. Endless transformations, endless ways. If you recover the gold in a mobile phone, then you lose the elusive rare earth element neodymium. This is a law of thermodynamics, which recycling cannot overcome. Switzerland, for example, both has one of the best functioning e-waste-recycling systems in the world, and ranks among the highest producers of e-waste (around 22 kilograms of electronic waste per person) and waste in general. While humans scour the earth's crust for raw materials, they not only eradicate environments, but fill them with new wasting materials[22].

Stories from the Long Life of a Smartphone

The point of departure for our collaborative research on the aesthetic and transmedial dimensions of *Times of Waste*, was the following question: Where do the leftovers from discarded smartphones go? What kinds of processes do these smartphones undergo, and what discourses and practices are involved to them? As we were attending to issues that had not yet been researched in detail in the field of arts practice, or had become topical only recently, our simple questions soon became very complicated. The smartphone contains so many elements. There are manifold possible ways of either disposing or furthering the life cycle of every section and/or component, and many gaps in those routes. Often, the companies are unwilling to disclose the details of these breaks. In addition, smartphones do not always follow the "conventional routes" of e-waste management, because they contain large amounts of reusable metals. They are normally not mixed and shredded like "conventional" e-waste, but taken directly to the smelter. Although there are a large number of gold smelters in the world, only a few smelt precious metals from scrap. Most of these are in Europe, and they even smelt e-waste from Africa that has been delivered through legal routes. One such route, for example, has been built between a state-of-the-art new dismantling factory in Uganda and a Belgian gold and scrap smelter that was founded during colonialism. Hence, although there are many routes through which e-waste is removed (in both legal or illegal ways) to the Global South, there are also some paths leading (back) to the Global North.

Approaching the smartphone as an assemblage of various components and matters continuously wasting anew, it was clear that we could not track routes taken by recycled smartphones by means of attached sensors. Instead, we relied on the situated knowledge of people working with waste, closely cooperating with waste disposal institutions, scientists, NGOs, and artists-researchers. Beyond e-waste's various routes to national dismantlers, shredders, and landfills, we explored numerous areas of recycling and waste disposal: the growing international market of second-hand mobile phones; laboratory processes using microorganisms to extract rare earth elements from household slag; the company Schweizer Metall-handels AG Deutschland, which trades so-called strategic metals (like rare earth elements); political initiatives; and cobalt and copper mining in the Democratic Republic of Congo.

Our research team assembled an extensive object biography of the smartphone, which we presented as an online archive and exhibition, including maps, sound, photographs, videos, and text[23]. An audio-essay, for example, relates the long life of the smartphone from the perspective of the element of neodymium, which narrates its origin as follows:

> *I came into the world as dust, as the remains of an exploded star. I embedded in the steppes of Mongolia and became a rare earth metal. I have been called Neodymium for 150 years. I am a chemical element and have many siblings. We are scattered all over the earth's crust; yet even in faraway wastelands it is worthwhile to extract us. Like all earth elements, we live in groups. I do so along with praseodymium, thorium, lanthanum, uranium. Humans wrest us apart, for we are needed in pure form. So uranium and thorium migrate into the tailings — waste lakes. Most of us are garnered in China. Cheaply produced, we are sold at a price. Our defense is our radioactivity, lung cancer for the miners. It is only with me that high-performance magnets consisting of iron, neodymium, and boron can be manufactured, those that are needed for the microphones, loudspeakers, and vibrators in the smartphone. I am multifarious. I've come a long way. And I am small…*[24]

We adopted this autobiographical micro-perspective to create a strange sense of intimacy with a non-human entity, and to defamiliarise our normalised (often hierarchical) attitudes towards our consumer devices. We wanted to challenge the unspoken "law" in science and critical art that you should not assume the speaking position of the fantasmatic (subaltern) Other. Interestingly, it was one of our research partners Patrick W.ger at the Empa — among others responsible for international audits of e-waste recycling — that fostered this idea. He supplied us with a conference paper in which he tried to overcome conventional scientific language by having the rare earth element neodymium speak.

Media theorist Jussi Parikka claims that we should conceptualise media according to a geological framework, as extensions of the earth. Quoting conceptual artist Robert Smithson, Parikka says: "Technology is made of the raw materials of the earth"[25]. Unexpectedly, our research was propelled in a similar direction, in that it came to emphasise how computers are a part of the cycle of geology, of sediments and rocks. Their main components both derive from the earth's crust, and return to it. Computers are zombies, write Parikka and Heitz[26]. They do not decay, as have I explained above, but only waste anew, for metals never die. Metals, in other words, not only live on and on after a smartphone's death. They also already have long histories, and long journeys behind them, before they are incorporated into devices. As one of our interview partners, Rainer Bunge from the HSR Hochschule für Technik Rapperswil and Times of Waste Research Team 2016, put it: "It is quite likely that a modern smartphone comprises at least a few atoms of copper originally mined during the Bronze Age".

We also learned that the greatest waste occurs not after but before smartphones are produced and used, in the process of mining raw materials. This was unexpected considering that smartphones' first-use life cycle is only short (between 12 and 24 months), and 3.8 billion smartphones were in use in 2018, which might have suggested a preponderance of wastage post-use[27]. Still, although the amount of smartphone e-waste after use is small compared to that of a printer or car, it is likely to increase, given that the global smartphone market has almost doubled in the four years from 2014 to 2018. Ever-new mobile phone gadgets accrue, which require almost 50 pure elements. Moreover, recycling rarely delivers purity, while mined elements are cheaper than recycled equivalents. As always, in the end it is a question of economy — an economy of wasting.

As part of the research project, we also produced a comprehensive sustainability scale with which to assess the production and use of materials. The first variables indicated on the scale are more positive from the point of view of sustainability than those towards the bottom of the scale:

1. *Sufficiency and sharing models*
2. *Longevity of products*
3. *Use of second-hand products*
4. *Repair of defective equipment (difficult with smartphones)*
5. *Re-use of individual parts / component recycling*
6. *Various levels of material utilisation (e.g., smelting metals) = classic recycling*
7. *Energy utilisation (plastic, etc.)*
8. *Regulated landfilling*
9. *Illegal landfill*

Remarkably, material recycling ranks sixth on this scale. This is due to the fact that even the best recycling involves major losses. However, recycling still produces less waste than excavating the earth's crust. The most environmentally friendly product is one that does not have to be produced — an unpopular message, which smacks of unsexy ascetics. But is it really more appealing to continue consuming into the distant future — indeed endlessly — through perfect recycling?

The e-waste situation can be summarised as follows: although certain countries have promised innovations and adopted reasonably good practices, there remains no overarching solution to the ongoing accumulation of an enormous volume of permanent e-waste. In fact, the picture is even worse. The United States exports 85 percent of its e-waste, having never ratified the Basel Convention, which regulates the transportation of hazardous waste and bans waste exports to the Global South. The European Union, for its part, does not properly recycle 65 percent of its e-waste[28]. Furthermore, rapid changes in the elemental composition of high-performance electronics (and their wastes) mean that there is no certainty about the long-term behaviour of slags. There is no ultimate solution, only indeterminacy, and wasting anew.

Discarded Data Contacts Us

The practice-based research project *Behind the Smart World* (2010–16) reveals strange entanglements among immaterial data, its material storage, and data-based control of people. A community-oriented laboratory project, it was led by *KairUs* (Linda Kronmann and Andreas Zingerle), in close cooperation with the Linz network cooperative servus.at (Uschi Reiter) and Linz's biannual festival *Art Meets Radical Openness* (AMRO)[29]. *Behind the Smart World* began by looking at 22 discarded hard disks that KairUs had bought in Agbogbloshie, Ghana, the world's largest e-waste dump. Using open source data recovery software, in cooperation with forensic experts, they managed to make the contents of six hard disks readable, although their former owners had deleted most of the data they contained.

KairUs passed these data, and the hard disks themselves, to nine artists (including themselves) for further processing. KairUs found "sensitive" material on two hard disks, which they processed for the trilogy *Forensic Fantasies* (2016). In one case, the disk's former owner in England could be tracked down via social media, complete with his current address and social circles. This resulted in part one of the trilogy, *#1: Not a Blackmail*, which consisted of a letter and a parcel containing the recovered data ready to be posted to the previous owner. In the other case, which resulted in part two of the trilogy, *#2: Identity Theft*, the disk contained recurring photographs of young white women from different dating portals, and other evidence of organised marriage scams. This hard drive, it seems, contained material from African romance swindlers. These people falsely pose online as the women in the images, feigning love with interested men. Romance scamming is a recognised problem in West Africa, and is addressed in the so-called "Nollywood" films. KairUs printed and hung the found images in an exhibition, combining them with found film footage so as to make the women unidentifiable. The third part of the trilogy, *#3: Found Footage Stalkers*, mixes and shows found private photos in the form of a family album. The trilogy is presented in analogue media — postal parcel, letter, picture on the wall, family album — as if the artists wanted to trigger a transmedial shift, in which the found digital "story" is told from another material perspective. Furthermore, the artists found it important that they did not profit personally from the wasted material, or cross ethical thresholds of privacy and surveillance. By choosing a conceptual, "dry" framing, they resisted the seductions of spectacle and exhibitionism. Refusing to act as wasters, they instead attempted to build a community of "recyclers-artists" starting from waste. Both *Forensic Phantasies and Behind the Smart World* demonstrate that today — in the age of Big Data and dataleaks — data are a resource,a new form of capital. Those who own other's data have power and make profit. Accordingly, Kairus do not approach data as it is economically valorised, but work through its material presence as both wasted matter and resource. They zone in on data's ability to generate haunting and unpredictable effects. In short, they reveal its im/materiality as a material force that always wastes anew.

Lithium: The Fallen-away of the Mother Mountain

Returning to the perspective of the "fallen-away", we might say that most resources — whether oil, gas, carbon, (precious) metals, or rare earth elements — were once waste, the "fallen-away"[30]. Oil and gas are remains of plants and animals that have sedimented over millions of years. Metals and rare earth elements are the remnants of stars that exploded in the wider galaxy, before falling to earth and becoming embedded in its crust. From the perspective of geological deep time, there even seems to be a certain similarity between the waste before and after its technological use. At both stages, waste settles over inhuman timescales, accumulating, sedimenting, and mobilising particles and entities on a molecular level. Indeed, small grey slags are reminiscent of mountain rubble. From the perspective of deep time, all these materialities come to share an identical character as fallen-away, transformative, and living. Still, although it may not always be productive to distinguish waste and non-waste from an inhuman aesthetic perspective, we still have to reconsider that in smaller, more human time scales there are qualitative and molecular differences, e.g. between fallen-away peb-

Joana Moll: CO2GLE, 2014
Courtesy of Joana Moll

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1. Research Team Times of Waste, landfill, 2016 [Times of Waste Research Team, "Metals never die," *Lost & Found, continent* 5[1], 2016, 11-13. Accessed January 30, 2019, http://continentcontinent.cc/.] Courtesy of Team Times of Waste
2. Research team *Times of Waste*: Exhibition Times of Waste–The Leftover, Museum der Kulturen, Basel 2017 Courtesy of Team Times of Waste
3. KairUs: Forensic Fantasies, 2016 Courtesy of KairUs
4. Unknown Fields Division: *We Power Our Future with the Breastmilk of Volcanoes /* Lithium Dreams, 2015/18 Courtesy of Unknown Fields Division

bles and the-fallen-away of depleted soil. Moreover, these differences have consequences for all organisms that live with, in and through these wastes.

The video *We Power Our Future with the Breastmilk of Volcanoes* / *Lithium Dreams* (2015/18), produced by English artists *Unknown Fields Division*, presents the raw material of lithium as both an astronomical and corporeal waste: an indigenous myth narrates of a volcano's female maternal fluids that have crystallised as a barren desert[31]. In footage of a drone flight over high Bolivian salt pans, recently the site of lithium production, we witness abstract images, patterns, and pools, whose colours change from poisonous greens to azure blues, such that this footage comes to resemble an abstract painting. A woman's voice speaks broken English. She tells of the Big Bang, which released elements that are sought after today; of the lithium that is increasingly needed in immense quantities in lithium-ion batteries for electric cars and similar "green" technologies; of the salt desert in the Andes that contains the coveted lithium; and of mountains that are sacred to her people. She relates the mythic origins of this plateau, explaining how it had been formed by the tears cried by the volcano mother for her lost lover, which mixed with the mother's flowing milk.

This giant's white waste is transformed into coloured fluidity, volatility, and dirt by a transnational factory. The video juxtaposes astronomical, geological, mythical, and capitalist dimensions of time and space. The beauty of the images, and voice's strange tranquillity, are set in harsh contrast with the forceful colonial excavation that imprinted the land with strange patterns. This aesthetic collision foregrounds the disproportionate temporality of raw material extraction: although mythical and deep times have reigned until now, geological materials are destroyed in no time at all. The verbal conjunction of myth — in the story of breast milk and tears — and progress — in the form of lithium evaporation — in the work's title generates a "desert-like" mood of acute pain. It repeats the mother mountain's ancient mourning, with a difference: the loss of the mountain's lover becomes a theft suffered by the indigenous population, who have different values and thus fewer rights. By connecting geological deep time with both mythology and accelerated machinic time, *Unknown Fields Division* reveals how various time scales obtain simultaneously in the present tense of the film. This strategy stresses how manifold perspectives and actors exist in the world, and that other temporalities, beyond the capitalist time of excavation, have value. Thus, the juxtaposition of the abject (in the form of dirt), wounds, and waste against beautiful visual abstractions allows us to experience non-linear progress and loss of control at both temporal and aesthetic levels. A transversal flux of cyclic events and affective subjectivisations is introduced: we see and hear cracks and fractures, we compassionately feel that something wrong is going on, and we sense that "green" technology is not the next step in the historical lineage of technological innovation. The film aesthetically conveys a sense that it is just a material variation, another stage of loss and depletion in times of waste. The video involves us in an excess of more-than-human mourning, combined with a paradoxical situation of simultaneous proximity and distance gener-ated by the drone's bird's-eye view. The affective aesthetic that emerges is strange and obscure, beyond conventional human perception. It offers an opening onto the previously unthought-of, the alien, and perhaps the transversal.

A project like *We Power Our Future with the Breastmilk of Volcanoes / Lithium Dreams* demonstrates that raw material production is waste production, and that a smartphone or green Tesla is always already waste. It reveals how the wasting of land amounts to what Rob Nixon terms "slow violence"[32], a continuous but often unrecognised destruction of the planet. Geologic sediments are literally evaporating; solid matter is dissipating into the air; lithium salt feeds the speed of the machine; and geological matter becomes part of atmosphere, dissolves into almost nothing, but still something. Two further elements of this complex transmedial project address this condition. One is a crafted glass battery[33] containing a mass of alternating aluminium and graphite anode and cathode, submerged in a lithium brine electrolyte collected from Bolivia's salt flat *Salar de Uyuni*. The battery creates a slow reaction, like the drip charge of a crying mountain. The other is *Uyuni Super Mine: History's Largest Multinational Mine*, a trailer by Jon Skerrit for something approaching a Japanese racer game. In it, we see the landscape flashing by become fuel for "our" racing car. All three works narrate variations of old myths of depletion and loss — still another form of waste that always wastes anew.

Transmedia-Waste-Aesthetics

Matter plays a crucial role in the current geopolitical discourse surrounding e-waste. It is restless, generative, and active, but also strange, opaque, and indeterminate. Scientists and technicians try to calculate degrees of uncertainty of waste materials' possible behaviour and develop strategies for dealing with this uncertainty. Institutional regulations assure us that everything is under control, citing regulations, laws, and other systems. Only when a catastrophe occurs and becomes public is the indeterminacy and dangerousness of living material assemblages acknowledged, often in a hysterical way, before they fall into oblivion once again. Modes of dealing with the indefinite and precarious against the background of our mortality, which constitutes the essence of our material existence, have been reduced to exclusive expert knowledge in the techno-scientific sphere. The aesthetic practices presented here intervene in this containment, closure, and repression of environmental knowledge. Although the artists seek contact with so-called experts, they use defamiliarising techniques to publicize waste's uncanny liveliness and materiality. All the projects use waste as an artistic material. Exposing the dump and working through its foreignness, they show how it is both a figure of thought and body of matter, which mobilises relations and queerness. Ironically, most toxic wastes endanger fertility and masculinity. All the projects link "e-waste" with "info waste" and "human waste"[34] revealing its geopolitical, post/colonial, and capitalist dimensions. All the projects are mediatised condensations of reality, which link theory and practice. Lastly, all the projects show waste as versatile matter and medium that affects humans, landscapes, matter, data, and capital.

The ontology of waste and transmedia aesthetics are profoundly similar. Both have the tendency to waste, to continually develop variations on the same story, and to preserve unexpected traces of original media and matter. Both render familiar things strange, disrupt smooth flows, and create a network of mobile relationships and meanings that transgress the boundaries of artworks' supposed autonomy. The transmedia-waste aesthetic inspires a strategy of mixing, blending, and commoning that goes beyond the dead ends of the Anthropocene. Knowing that there is no ultimate solution to the Wasteocene, these modes of living and acting reject fantasies of finding a single global resolution. Where there is the problem of borderless wasting, there is no ultimate elimination, no technical solution possible. There are only actions that relate to others in ways that vary dominant modes of wasting, which, as Armiero says, are based on "consuming and othering". If there is hope, it is in small-scale relations that grow, distribute, and infect others, actions that waste, always anew, in a paradoxical way. Unsuspected resistances might be at work in such dynamic relations, deadly forces that might have transversal potential—or might not.

Notes

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8. "Wastocene" plays not only on the term Anthropocene, but all the other geological "-cenes". We adopted this wordplay in our research project Times of Waste [see endnote 2]. Environmental historian Marco Armiero coined the term *Wasteocene* for similar reasons. His lecture *Welcome to the Wasteocene: Sabotaging the Anthropocene through Guerilla Narrative,* Armiero writes: "Waste can be considered the essence of the Anthropocene, embodying humans' ability to affect the environment to the point of transforming it into a gigantic dump. For this reason I have argued that this new epoch might be called the Wasteocene" [Armiero and De Angelis 2017]. However, the Wasteocene frames waste not as an object – "waste" – but as a relation – "wasting". My hypothesis is that while wasting relationships are based on consuming and "othering", that is, on sorting out what and who is waste, commoning practices are based on reproducing resources and communities. https://www.space4235.com/archives/fumogeni-2-marco-armiero[accessed January 28, 2019].
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21. See Times of Waste Research Team 2018.
22. Hird, Myra J., "The Phenomenon of Waste World Making"*, In Rhizomes,Cultural Studies in Emerging Knowledge* 30, 2016. Accessed January 30,2019, https://doi.org/10.20415/rhiz/030.
23. The object biography is a method adopted among others in sociology, anthropology,and history [Appadurai 1986; Kopytoff 1986]. It investigates and constructs the life and career

of a thing like the life and career of a human being. Doing so, it processes generic lifespans of exemplarily chosen things, in order to grasp their global and historical entanglements.

24. See Times of Waste Research Team 2015-18b.
25. Parikka, Jussi, *The Anthrobscene,* University of Minnesota Press, Minneapolis,MN and London, 2015a, p.5.
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29. http://kairus.org.
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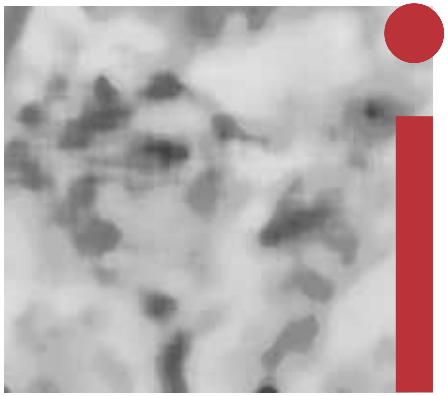


Inflation

Temporary illusions, the present always looming larger than the past, past changes dwarfed by new challenges, present blotting out the past, networks crawling fibre, new languages, again, hush be silent learn again, silent life of trees, networks roots communication, silicon lives in endless repetition, giga into tera into peta into exa into zetta, blockchain consuming the world, will the network inflation translate into neurons?

Here the eternity of networks, communication exploding into bytes, logic of hazard, a game, nodes infinitely multiplying, crawling bamboo spiders turning back on big bamboo bang, silicon eternity without time, then again nanosensors descending into chlorophyll, silent throbbing submarines descending into listening for the something feeling reacting leaves translating light light becoming feeling – when will we grasp the living feeling sentient gaia everything is everywhere in us, inflation of being, or inflation of love's labour's lost in meandering inflation of play-in-play in silicon disrupted by global warming ohoohooohhh that inflahation rag but somewhere it ends and returns to the simple questions, my life is your life is anyone's life to be measured with solitude mere feeling, is the way to inflating peace in the world the humble work of becoming more human each day?

Forever-do

horaica

My Data and Me: una storia d'amore

Forever-do

Artist
Jill Townsley

Scientists
Carlo Ferigato
Angela Gianesin
Adam Lewis
David Shaw

Collaborators
Daniele Mancini, Otolab
MC3 research group,
The University of Milano-Bicocca

Forever-do
SciArt Datami project 2019
Forever-do Game, cardboard boxes, mediums
Forever-do Infestation, sculpture: bamboo sticks, tape

Forever-do Infestation,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view
at the Gauss Lab [detail]
Photo Jill Townsley

The Forever-do Project & Collaboration

Jill Townsley

The *Forever-do Project* explores the idea of *fishing* into data sets generated by coordinated behaviours. The aim is to catch coherent patterns of data and represent them in visual artwork. *Nets*, traditionally a fisherman's tool, are also the link between the art and science used in *Forever-do*. In theoretical Computer Science, nets are instruments for the analysis and design of systems, distributed in time and space. The strength of these nets is their explicit representation of fundamental situations of coordination and concurrency among system agents. Agents can be computers and/or human beings. Nets were introduced as formal Computer Science tools by Carl Adam Petri in the nineteen-seventies, and are today known as *Petri Nets*. One of Petri's examples, the *Bucket Chain*, is a simple explanation of coordinated behaviour between firemen extinguishing a fire, as they carry water from the tank to the fire using a chain of buckets. This sequence explains how the coordination of behaviour and flow of data in time and space can be represented with nets. The Bucket Chain is the main source of inspiration for the *Forever-do Project*.

Meeting within the context of the JRC, and in response to the Big Data question, we (artist Jill Townsley and computer scientist Carlo Ferigato) realised that that process holds an important position within both of our working practices. Research around the design of communication systems, and the emphasis on the process within the art object (definitive beyond subject and object), presented some common ground. Articulating our processes offered a rich dialogue and exchange of creative thinking, identifying important key words beyond process, such as system, time, space, flow, coordinated behaviour, repetition, difference, unfolding, folding, choice, resource, selection and transfer. These words offered a common language with which to articulate the possibilities of reading across our respective fields, in order to develop an artwork that had some correspondence with coordination and communication (as identified by Petri Net theory). Put into a slogan, we became fishermen, fishing across disciplines into the sea of Big Data sets in order to extract coherent patterns and procedures, pertinent to Petri Net theory, that could be visualised as art. From this, we have developed two symbiotic artworks, the *Forever-do Game* and the *Forever-do Infestation*.

The Forever-do Game

Artistic activity is a game, whose forms, patterns and functions develop and evolve according to periods and social contexts; it is not an immutable essence.
Nicolas Bourriaud, 1998[1]

The *Forever-do Game* is a socially relational public artwork or happening, in which people flow around a

Forever-do Game,
Resonances III Datami
Carlo Ferigato,
Blacboard drawing, The BucketChain, 2019

physically networked space by following a set of instructions. This activates coordinated interactions between players, who meet causally at random places in space and time. The game mirrors the theoretical construct of a Bucket Chain network, a simple form of Petri Net system, positioning the game within today's digitally networked age. The socially coordinated nature of the rules-based system, that the players travel, is in itself a socially related construct. A construct that rationalises data flow, making visible the hidden nature of all data flowing within our Big Data systems. This presents us with a symbiotic relationship between scientific theory and art practice. The first manifestation of this work was played during the Milan Digital Week in March 2019, in the *Palazzo dei Giureconsulti*, near the Duomo, with the collaboration of the MC3 research group on concurrent systems at the University of Milan Bicocca. The game was repeated for the Resonance III Festival, with further digital possibilities developed in collaboration with artist group Otolab, and the application of Radio Frequency Identification tracking (RFID).

The Forever-do Game 1 – Milan Digital week

Visitors to the Digital Week in Milan were invited to participate in a live variant of Carl Adam Petri's Bucket Chain, an example of a simple Petri Net process. Armed with brown or white boxes containing an everyday object: a knife, a fork or a spoon.

Participants travel through the meshes of a physical (yet invisible) net, moving between coloured doormats placed on the floor. When individuals meet at a mat, they open the box to compare the contents. Depending on the local circumstances concerning the similarity or difference of those contents, players encounter one of two consequences:

1. They continue to flow around the game: this happens when their compared objects are different (non-repeated) – then the objects are exchanged and the *Forever-do* continues.

Forever-do Game,
Resonances III Datami
Festival JRC Ispra site
15 October–8 November 2019
Installation views, Building 100: boxes with different instructions on the lid [there are 34 sets of instructions], players in the game
Photos Jill Townsley, Pierre-Stuart Rostain

2. They stop and exit the game: if the objects are the same (repeated) then players are asked to leave their boxed object behind, placed on a tower at the point of coordination.

In this way a causal flow happens, when non-repeated coordination occurs. Objects are exchanged and continue their journey, independent of player or box. Alternatively, when repeated coordination occurs (people meeting with the same objects), the flow is halted and boxes build up around the mats. Over time the number of boxes in the towers are gathered randomly around the mats, forming a sculptural installation. The installation reveals a poetic data trail of coordinated human interactions, recording the incidence of two people meeting at a mat and finding that through random chance, their boxes contain identical objects.

The coloured doormats act like nodes in a giant network. Receiving the flow of information (as people and boxes move from mat to mat) enabling coordination (places for human interaction). Doormat nodes, that mark the place for the coordinated behaviour that either rests the player, the box or the object from the flow of the game, or, moves them on in order to continue the journey – the *Forever-do*.

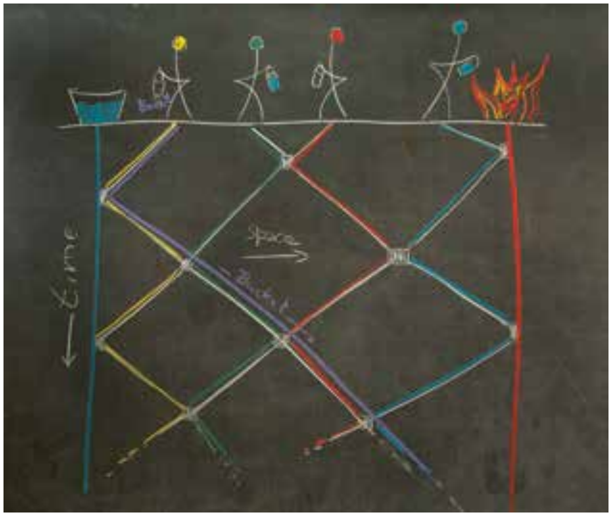
As the box-towers grow, data may be extracted from the game in many different ways. The piles of white and brown boxes could be interpreted as binary code. The number of boxes clustered around the coloured door mat also give that mat an integer value. From this data, new digital, conceptual and physical constructs may be developed. Reorganised data is used to form a new sculpture: the *Forever-do Infestation*. Alternatively, a new event or happening could be derived as presented in the *Forever-do Game 2*. In other words, a new fishing expedition can begin.

More generally, the gathering, reorganisation and extraction of information, as presented in the *Forever-do Game* installation, is indicative of the way data flows today. Data (collected in a myriad of ways) flows forever through our digital systems. Systems and data unimaginably vast in form, yet invisible in time and space. This data can be organised and extracted in whatever way society chooses: it can be reorganised and extracted to help us do great things for humanity, such as understand diseases; or it can be used less responsibly, to smartly target us to purchase more mass-produced goods.

The Forever-do Game 2 – Collaboration with Otolab – Resonance III Festival

The game is extended for the Resonance III Festival through collaboration with the artist group Otolab. Intangible elements, held in the process of the game, such as the movement of the boxes, are now made more visible, by tracking the causal flow of each box, from doormat to doormat (nodes), using Radio Frequency Identification tracking (RFID). This provides a wealth of additional data; information that can be represented through graphical representation. This enables even more categories of identification, classification and representation. Offering the viewer a multiplication of formal data gathered from the causal flow of boxes carried by people playing a game.

The tracking and visualisation tool created by Otolab,



Forever-do Game,
Resonances III Datami
Carlo Ferigato,
Blacboard drawing,
Bucket Chain Unfolding, 2019

Forever-do Game,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view, Building 100
Photo Jill Townsley

extends the reach of the game from its local administration to a much larger web of connectivity. The digital tracking and data representation will be streamed across multiple platforms; on screens and projections within the space of the game.

Presented across these analogue and digital platforms, the game propels its human participants on a global journey that mirrors a causal flow of data. It also works to make visible a physical link between human interaction and data flow. A symbiotic relationship placing the individual within the data whole – presenting the consequential referral, of self to network, and network to self. In this way, the *Forever-do Game* defines its *Datami* as an organic consequence of cause and effect within a greater and ever flowing whole.

The Forever-do Infestation

> *Contemporary art escapes the present not by resisting the flow of time but by collaborating with it. It produces artistic events, performances, temporary exhibitions that demonstrate the transitory character of the present order of things and the rules that govern contemporary social behaviour. Imitation of the anticipated future, may manifest itself only as an event not as a thing.*
> Boris Groys, 2016[2]

The *Forever-do Infestation* takes its structural form from an unfolded Petri Net, as symbolised in the `Bucket Chain' network. The two-dimensional graphical depictions of the `Bucket Chain' structure unfolded is contorted in three-dimensional space. The nodes are a joining point for 1500 bamboo canes that make up the body of the Installation.

The Infestation also has colour flowing through its network. The colour moves through the shape in a way authorised by data from the *Forever-do Game*. The coloured doormats in the game (red, blue, yellow and black) translate into colours flowing through the Installation. Places of meeting within the game become nodes in the installation. A binary code from the box-towers, deposited by players at a coloured mat, authorise a system of flow through a node:

- Brown box – flow goes straight-on
- White box – flow changes direction

Collective player coordination and interaction (in the game), become data that authorises a system based modular structure (in the Infestation). A structure that interacts with a building, separate to the action of the original communication between people. This is a multiplication of data, shifted through material (animate and inanimate) and moved through time, space and place.

The Karl Friedrich Gauss Laboratory

The siting of the sculpture at the Karl Friedrich Gauss Laboratory is important to the development of the overall Infestation, its structural form and its concept. The relationship between the site and the form is indicative of an installation rather than a stand-alone object.

The Laboratory was built specifically as a Test Facility for Humanitarian Demining Technology, within the

Sign Humanitarian Demining,
JRC Ispra site, 2019
photo Jill Townsley,

Forever-do Infestation,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation views, Gauss Lab
Photos Jill Townsley,
Federico Gianoli

Forever-do Infestation,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view, Gauss Lab
Photo Jill Townsley

then JRC Institute for the Protection and Security of the Citizen. It was built in 1999 to test and evaluate equipment used in detecting landmines in humanitarian operations, often following wars. Its most important use was in developing UN Mine Action Standard test methods for metal detectors. Adam Lewis[3], from the JRC, worked on the development of the research lab and co-authored this explanation:

> *The objective was to provide a facility, which could be used to establish a basic signature database of anti-personnel-mines and to allow validation, verification and benchmarking of equipment. The sensor data that would be derived was to be made available to the R&D community to facilitate the proving of data fusion algorithms by developers of equipment aimed to improve the effectiveness of civilian demining.*

The Gauss Laboratory building was constructed with as little metal as possible, to avoid spurious signals when operating metal detectors and ground penetrating radar. Giving this "noble" building the exterior appearance of little more than a very large garden shed. Anecdotally, the choice of name was regarded humorously by the researchers, because a wooden hut, used for a very practical purpose is named after an exalted philosopher of basic science, Carl Friedrich Gauss of Göttingen. He was a great 18th-19th century physicist and mathematician whose ideas underpin the theoretical basis of technology like metal detectors and magnetometers.

The Gauss Laboratory stands now in disrepair, unused, and due to be demolished next year, since the project was closed at the end of 2006. It became apparent, in part because of the laboratory's own research, that the effort needed for the development of a sophisticated device, incorporating several different types of sensors, was much greater than had been expected. This required more money, money that might be better applied in other ways considering the broader socio-political contexts. In other words, the data flowing from the Gauss Laboratory, while productive of new understanding, also contributed to the shift of research away from the laboratory itself. A suicidal return of data that through its free flow destroys its point of origin, while still being indicative of good experimental insight. Today, the European Union continues to fund different aspects of humanitarian action on landmines, through its External Action Service.

The *Forever-do Infestation* is sited here in response to this once functional, but ultimately, self-sacrificing building. The Infestation engulfs the laboratory with a physical structure whose conceptual origins represent the invisible flow of data between the tangible and intangible. It infests the space around, blurring its silhouette and moving it further away from its functional origin. Yet at the same time it also marks the place of experimentation for the laboratory and the artwork.

Nicolas Bourriaud in his book *Relational Aesthetics* (1998) refers to Maurizio Cattelan's phrase of the *dolce utopia*, the idea of constructing "temporal spaces which permit for a while experimentation". The essence of this idea has been very important to the development of the *Forever-do Project* as a whole, and is indeed central to the philosophy of the SciArt mission.

From the very start, the commissioning body has been clear that the collaboration between artist, scientist and policy maker, is central to the overall intent. This has placed emphasis on the process of collaboration, practice and presentation rather than the final result. This is a brave way of constructing something that we may call "art".

Within art history and critique, there is still a great deal of consideration given to either the subject or object of arts practice. Despite a move towards processor systems-based arts evident since the 60s and 70s, the matter of object and subject in arts practice still holds the centre ground for critical discourse. There are increasingly many pushing against this, Bourriaud being an important figure. But, by thinking about art as a process or event, a relational, societal and social place is offered for authorship and realisation. This is not only the post-modern reform of authorship, deferred or shared, but authorship within the moment of a continuing process - the *Forever-do.*

This conceptual space made real through events also requires a temporal place, referring back to Cattelan's *dolce utopia*, the idea of constructing temporal spaces (physical and conceptual). For the *Forever-do Game*, it was the place of the *Palazzo dei Giureconsulti* at the Duomo in central Milan, temporarily occupied by Milan Digital Week. Milan Digital Week is itself a social construct, a temporal event into which interested parties (visitors and participants) occupy space temporarily. Visitors are in this way already complicit within the flow of events. The place of the *Forever-do Infestation* is also similarly contingent, built temporarily around a research laboratory now mothballed, out of step with socio-political convention and capital power, working in a way Groys describes in his book *In the Flow* as a:

> *Temporary exhibition(s) that demonstrate(s) the transitory character of the present order of things and the rules that govern contemporary social behaviour.*
> Boris Groys, 2016[4]

An installation where the authorship is shared via data from all the people who played the *Forever-do Game*. It infests the space of the Gauss Laboratory, overpowering it, just as data had a primal role in both forming and ending the research that built the laboratory. Or perhaps, the installation is protecting the memory of the Gauss Laboratory, marking its *dolce utopia* as a temporary place of experiment.

Looking forward to a future from the 1970s, Petri outlined a path to help us all deal with our complicit role in society's data communications. In a lecture entitled *Communication Disciplines*, he laid out a set of conceptual tools that proposed a new theory in communication system design:

> *…computer technology supplies us not [just] with a medium for artificial intelligence nor with a machine which may be used solely for computation, but with a medium for communication and for strictly organised information flow, a medium which may induce major changes in the modalities of co-operation between human beings.*
> Carl Adam Petri, 1976[5]

Using Petri's twelve communication disciplines as a mechanism for analysis, it becomes evident that the choice is ours. The value of our data depends on how we reorganise and extract it. How we identify future compositions of need, or problems to be cancelled or solved. Addressing and naming those needs/problems correctly, in order to synchronise our behaviour, to model and delegate, authorise and copy it across our Big Data networks. To effectively support 'co-operation between human beings'.

Petri Nets Communication with automata

Carlo Ferigato

The history of *Petri Nets* can be traced back to the PhD thesis of Carl Adam Petri in 1962[6]. His aim was to establish a new theory of communication based on two assumptions:

a) there exists an upper bound on the speed of signals;
b) there exists an upper bound on the density with which information can be stored.

These assumptions can be considered as natural ones today, but they were not so natural in the sixties of the last century, when the theory of automata as abstract computing machines was developing rapidly and, sometimes, without regard for its potential limits in actual hardware realisations.

As a consequence of these natural assumptions, Petri analysed the subject of "information flow" in a new way, based on the relations between structure and behaviour of automata and on the role of information as a resource in communication.

In his view, communication becomes an organised

Gauss Lab when working
JRC Ispra site
Photo JRC Archive

activity involving automata and people. *Communication with automata*, the title of his PhD thesis, refers precisely to this organised activity where "with" has the double meaning of "between automata and people" and "using automata as communication medium". Considering automata as organised communication mediums, as we do today through the Internet for example, Petri opened the way to new applications of the discipline "pragmatics", as a branch of linguistics, in view of a modern theory of communication systems.

Concurrency

The more formalised part of Petri's work, which is also the more studied in scientific literature, deals with a specific aspect of communication: coordination of concurrent agents.

While representing the evolution of a system, a system's process, a standard technique consists of ordering in time the global states of the system itself as if they were subsequent snapshots. This view contrasts with assumption a) above on the limit to the speed of signals since any snapshot should collect signals at the same point in time from distinct system's components distributed in space, which is clearly impossible.

Petri changed perspective and considered as basic elements local states of a system as opposed to global states or snapshots, and local changes of local states, called transitions. Local states and transitions are not assumed to be ordered by any global clock but by a flow relation indicating the causal dependence between local states and transitions. Let us consider a variation of the Bucket Chain example above due to Petri as well: imagine four sentinels — red, blue, green, and yellow — whose duty is to patrol the shores of an island as in figure 1.

The explicit infinite repetition of the orders the sentinels have is:

> *… walk following the shore until you meet another sentinel, then turn on your heels and walk in the opposite direction until you meet another sentinel, then turn on your heels and walk in the opposite direction until you meet another sentinel, then turn on your heels and walk following the shore…*

In figure 1, sentinels red and blue are about to meet at α while sentinels green and yellow just met in β. Figure 2 represents the detail of the meet event between blue and red and figure 3 is its representation as a net with back and forth paths drawn as distinct arrows.

Figure 1: four sentinels patrolling an island
Figure 2: blue and red sentinels meeting at α
Figure 3: net representation of blue and red meeting at α

Each sentinel is an independent agent that walks forever concurrently with the other sentinels. Eventually, sentinels change their respective directions at the meeting points, where coordination happens. The explicit representation of concurrency and locality is the key for the formal representation of processes via nets.

In the language of nets, persistence in a local state is denoted by circles that can be seen as logical propositions on the system. Transitions, as changes of local states, are denoted by squares; the flow relation, ordering all states and transitions two by two, is denoted by arrows linking squares and circles in the appropriate directions.

Process nets

By continuing with the example above, the sentinels have four meeting points along the shores: α, β, γ and δ (see figure 1). These meeting points are not fixed once and for all, since they depend on the relative speed of the individual sentinels. These meeting points are the squares in the drawings below, while propositions on the two possible directions of walk of each sentinel, say "walking right" or "walking left", are the circles.

The paths followed by the blue and the yellow sentinels are highlighted. In figure 4 the (infinite) process of the four sentinels is represented while in figure 5 the respective paths in space and time of the blue and "yellow" sentinels are in evidence.

Figure 4: The net representation of the process for the four sentinels (process net)
Figure 5: Paths for sentinels blue and yellow in the process net

In a process net, time and space are not related to any metrics: measurement of time is substituted by the order given by the flow relation.

Abstractions of process nets, net systems

Regular patterns can be extracted from a process. For example, the repetition of the meetings and change of direction by sentinels blue and red in figure 3 are in evidence in figure 6:

Figure 6: Regular patterns for the meetings of blue and red sentinels in the process net
Figure 7: The abstract representation as a net system for the process of the four sentinels

The repetition of regular patterns can be exploited for a more compact representation of a system. The abstraction of the recurrent meetings between sentinels blue and red is represented in figure 3, while the abstract (and compact) representation of the whole system is represented in figure 7. Both the compact system net representation in figure 7 and the explicit process net representation in figure 4 contain, in some sense, the same information and each representation can be converted, under certain assumptions, into the other.

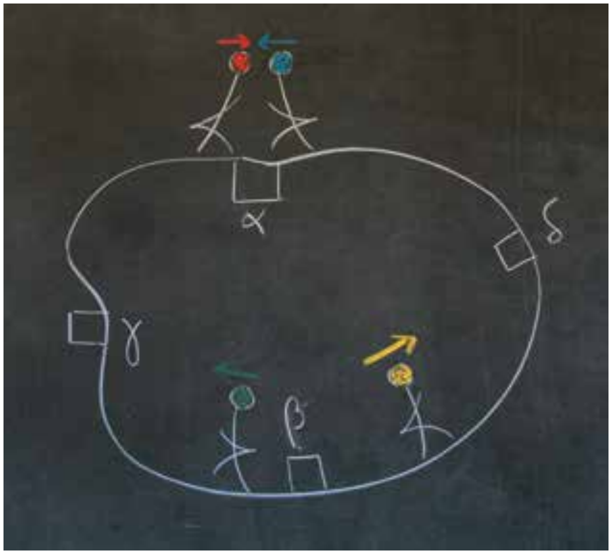
The evolution of the system, explicit in processes, needs for a further ingredient in system nets: the firing rule. By exploiting truth and falsity of the propositions representing local states, a transition of a system net can fire when all its input states are true and all its output states are false. This situation before and after the firing of transition α is represented in figure 8 and 9 with tokens in the input local states of α and, respectively, in the output local states of α.

Figure 8: Situation in the net system before firing of α
Figure 9: Situation in the net system after firing of α

Intuitively, the abstraction from process nets to system nets corresponds to changing the orders to the sentinels from the infinite explicit repetition as given initially, to the following, finite orders with a *Forever-do* at the beginning: *Forever-do*: walk following the shore until you meet another sentinel, then turn on your heels.

Notes

1. Bourriaud, N. *Relational Aesthetics,* Les Presses Du Reel,1998, p. 11
2. Groys, B. , *In The Flow,* London and New York, Verso, p.3, 2016
3. MINETEST - Test support to R&D Actions, International Projects and Related Technical Workshops J T Dean [ed.], A. J. Sieber, J. Fortuny-Guasch, B. Hosgood, A. Jones, A Lewis, S. Lewis and G. Nesti Inst. For the Protection and Security of the Citizen European Commission, Joint Research Centre, 2002.
4. Groys, B. , *In The Flow,* Verso, p.3, 2016.
5. Petri, C, A. , "Communication Disciplines" published in *Computer Systems Design: Proceedings of the Joint IBM* [B.Shaw edt], p.171-172. The disciplines were suggested by Carl Adam Petri in September 1976, during a lecture given at Newcastle University entitled 'Communication Disciplines' later published in *Computer Systems Design: Proceedings of the Joint IBM* [B.Shaw edt], 1976.
6. Petri, C. A., *Kommunikation mit Automaten,* Dissertation, Schriften des IIM 2, Rheinisch-Westfälisches Institut für Instrumentelle Mathematik an der Universität Bonn [English translation: *Communication with Automata,* Technical report RADC-TR-65-377, Volume I, Final Report, Supplement I], 1962.



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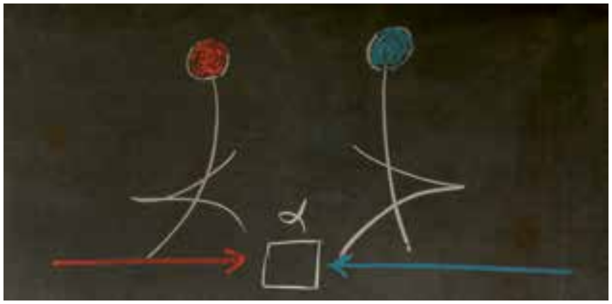

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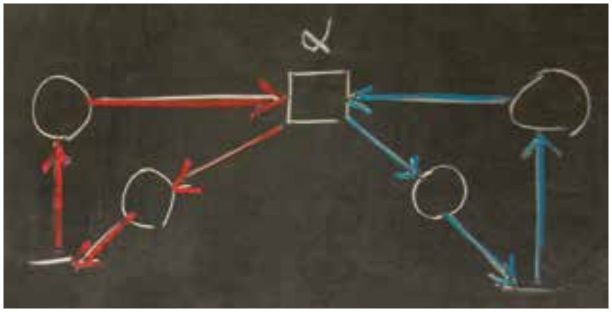

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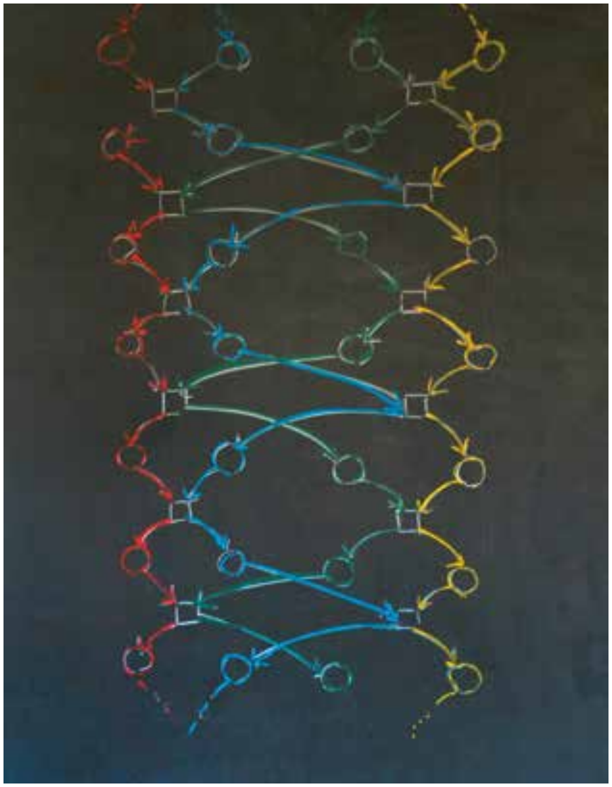
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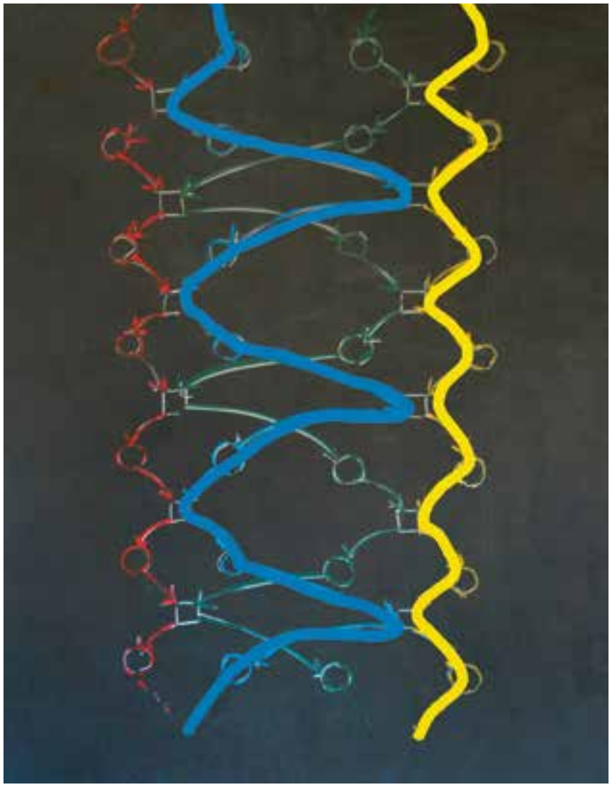
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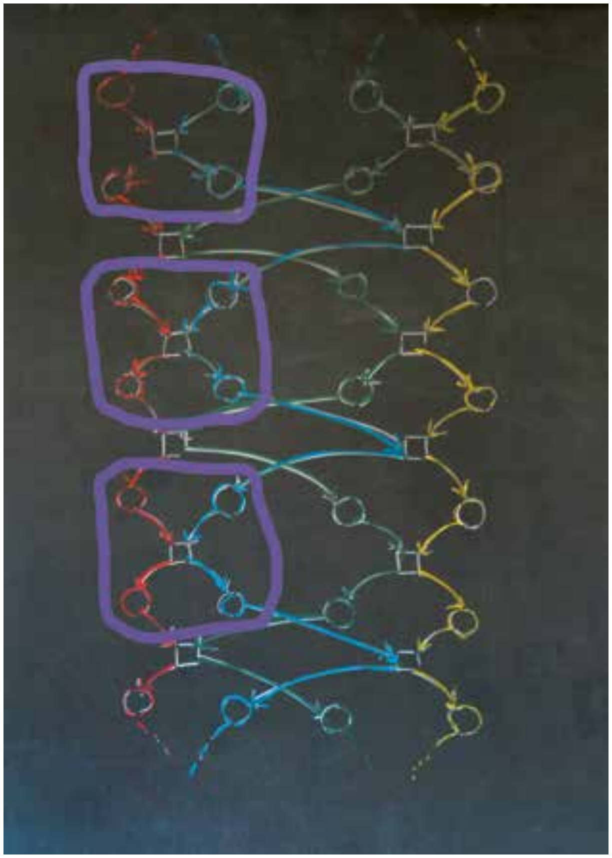

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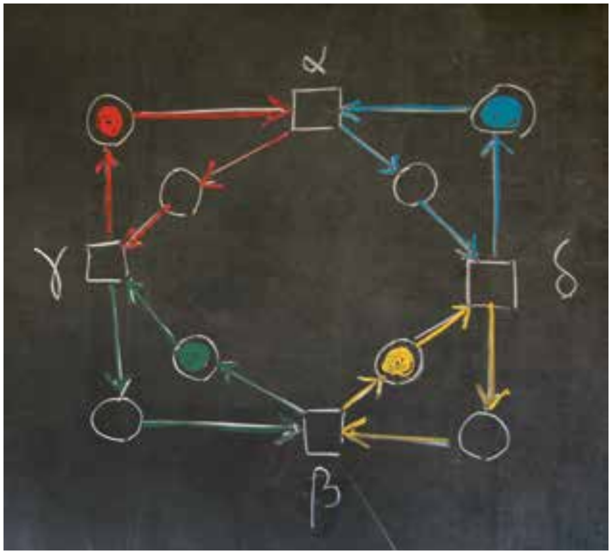

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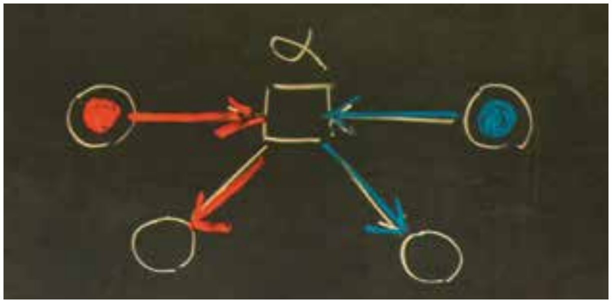

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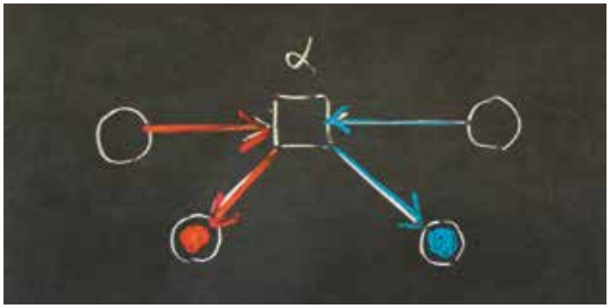


9

Forever-do Game,
Resonances III Datami
Carlo Ferigato,
Blackboard drawings
for *Forever-do,* 2019

1. Island Sentinels
2. Basic Meet Event
3. Abstract Representation
4. Process Unfolding
5. Zigzag Unfolding
6. Process Unfolding Repetitions
7. Sentinels System
8. Meet at Alpha System before
9. Meet Alpha System after

horaica

Artist
Akitoshi Honda

Scientists
Pascal Colpo
Diana Rembges
Andrea Valsesia

Collaborators
Anne-Marie Heydeck
Markus Richter, Beuth Hochschule

horaica,
SciArt Datami project, 2019
Interactive installation: robots, plant, sensors, software

horaica,
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 – 19 January 2020
Installation view
Photo Akitoshi Honda

horaica

Akitoshi Honda

Short description

horaica is an art-science installation that tries to enhance plants' capability and understanding (feeling/seeing) of our local environment through their senses. It does so through a spatial artistic installation that interacts with the visitor.

The title of the artwork comes from the name of the ancient Greek sister goddesses, the *Horai (*aka *Horae, or Hours)* - goddesses of seasons and natural portions of time.

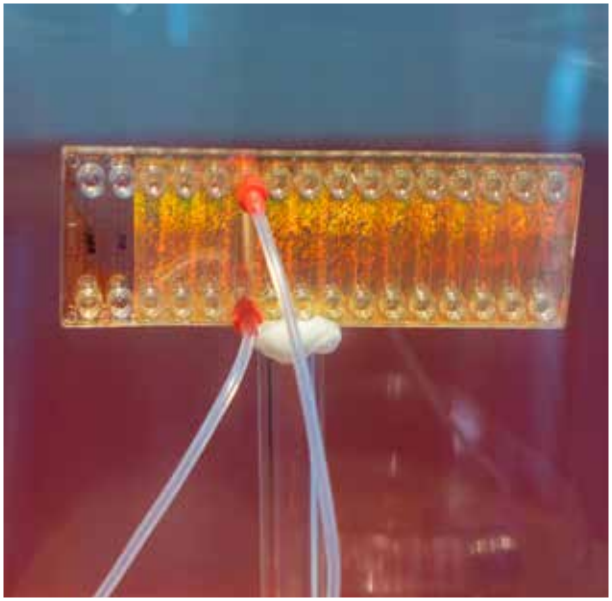
Concept

As humans, we have included plants in our urban landscape ever since we began to construct cities. An early example are the hanging gardens of Babylon, but the meaning of small pieces of nature in urban environments, this *urban nature*, has not changed much over the past few thousands of years.

There are certain plants in urban environments that have particular functions. Memorial trees or religious trees, such as those in the Japanese Shinto shrines[1]. Some plants are even displayed as artworks, such as Joseph Beuys' 1982 project, 7000 *Eichen – Stadtverwaldung statt Stadtverwaltung (7000 Oaks – City Forestation Instead of City Administration)*. Other plants have practical purposes, such as acting as barriers against sand or wind. Nevertheless, the main overall function of plants has not changed in centuries. We just plant plants.

Plants react to their local environment 24 hours and 7 days on a row. They are simultaneously environmental sensors and data repositories. Furthermore, plants recognise and react to their environment in different ways and on a different timescale compared to how humans recognise and react to the environment.

The artist's ambition is to equip plants with modern technology and use an artistic installation expe-



horaica,
Resonances III Datami
Details, 2019
Photos Akitoshi Honda

rience to allow people to understand these local environments from the plants' point of view.

The artwork

There are lot of works/projects using plants as motif/materials with technology in recent art history, such as the Kirlian photography method from the late 19th century. With the development of cybernetics in the latter half of the 20th Century, plants equipped with electronic devices have become popular, allowing their "sensing" to be monitored. Since then, many artworks have adopted a similar method. One example being the performance of John Lifton, Tom Zahuranec, Jim Wiseman and Richard Lowenberg, in the film, *Secret Life of Plants* of 1976[2].

The artwork *horaica* focuses rather on the relationship between human (urban) environment and plants. Instead of focusing on than on the interaction between plants and humans or plants alone, the artwork *"horaica"* is centered on the relationship between plants and a human, urban environment. In *horaica*, the plant is equipped with various sensors and made mobile by means of robots. This allows the plants to 'explore' their local environment.

A plant itself is installed in a chamber that is isolated from the environment, and separated from its root area, which is kept in water[3] for two reasons: to minimise the effects from bacterial activity in the soil and for artistic, aesthetic reasons. Several sensors of the same type are set up in and outside the plant chamber to determine differences between general environmental states and changes caused by the plant itself. This should allow the plant's true activity to be measured.

At the same time, the coordinates of each robot are stored in a database together with measured sensor data. With this coordinates' data, it becomes possible to see each plant's activity: not only its stationary position, but also all its different positions within different environments. For example, the plant can 'choose' to stand near the window – where it finds more sunlight – or in a corner – where it finds more humidity, less sunlight, etc.

The data from sensors and coordinates are stored in an online databank and processed with the help of a simple machine-learning method to determine if the plant's activity is more or less active, compared to other data with similar conditions (temperature, humidity, characteristic of light) from past records. This result is then presented (or represented) as the plant's "emotion" in an augmented reality (AR) application described below, by means of a specifically developed expressivity.

The AR application shows the plant's chronological activity as a virtual, spatial artistic installation. The plant's activities are represented on three different levels. Happy (more active than in similar environmental conditions in the past), calm (as active as in similar past environmental conditions) and sad (less active than in similar past environmental conditions). These "emotions" are represented as virtual plants in the augmented reality space that sits atop the real physical space: a flower indicates a happy status, a green plant a calm status, a dead tree a sad status. As a result, the visitor can see a "forest of the plant's emotions" and observe the local environment through the plant's senses.

Technical details

To realise the project, we needed to measure the plants' activity in real-time and in a non-destructive way. Many parameters can gauge a plant's activity. We developed our own method using certain criteria:
- Non-destructive continuous real-time automatic measurement.
- Relatively easy set-up (without huge measurement instruments).

With the above criteria, we collected the following data, allowing us to determine a plant's activity:

- Sucrose intensity of plants
- CO_2 consumption
- Humidity effected by plants
- Leaf temperature
- Leaf area index (LAI) [4]

- Water consumption by plants
- Local environmental air temperature
- Local environmental visible luminosity intensity
- Local environmental light spectrum intensity

Sucrose intensity of plants

The sucrose intensity is one of the most important vital signs of a plant's health.

To measure sucrose intensity, we developed, together with Andrea Valsesia from the JRC nano-biotechnology laboratory, a special nano-sensor. This sensor determines the amount of sucrose in the plant's sap – which we then read as sucrose intensity. We tried to obtain real-time measurements from the living plant, but collecting sap automatically creates a specific difficulty (of survival for the plant?). We therefore considered a manual method to measure the sucrose intensity with a model plant, correlating the data and analysing them together with other data elaborated with machine learning, using the expected sucrose intensity based on mathematical models.

CO2/Humidity intensity

CO2 and humidity intensity is also a major indicator for a plant's activity. If plants exchange gases with the environment, their stoma is opened and as a result, humidity in the chamber raises. CO2-intensity is a crucial factor to determine if plants are doing photosynthesis. To measure CO2 and the change in humidity caused by plants, we used the same sensors inside and outside the plant's chamber, to determine the difference between the two environments.

Temperature/Environmental luminosity/spectrum intensity

Light condition is another crucial factor for a plant's life cycle, as it includes photosynthesis activity. We measure luminosity and spectrum intensity (410nm, 435nm, 460nm, 485nm, 610nm, 645nm, 680nm).

Temperature is also measured at two positions, inside and outside the plant chamber.
These measurements were used to determine how plant activity is correlated to the local environment.

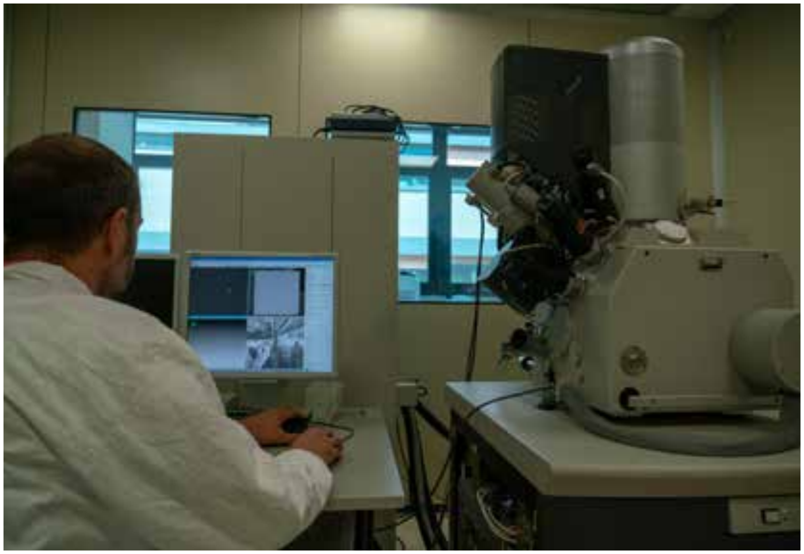
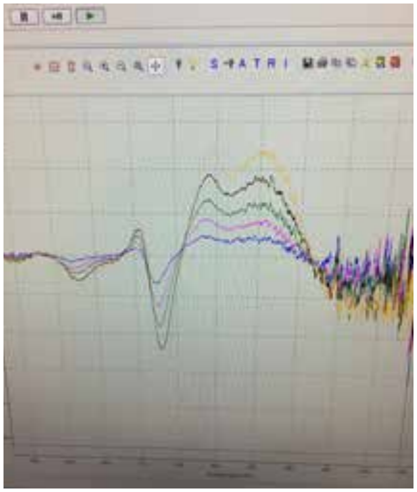
About the type of sensors used

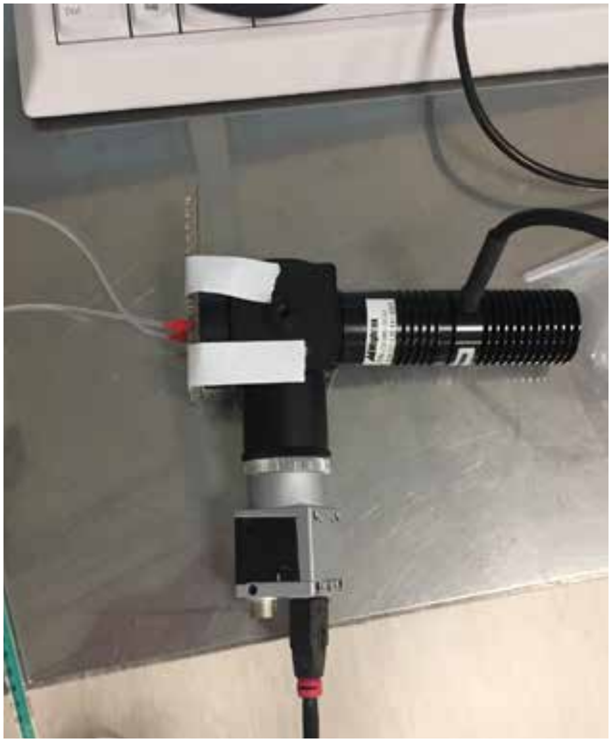
Advancing technology such as MEMS[5], allows for small sensors with low power consumption. These are by now widely available in the market. Taking these measurements is no longer limited to specialised lab equipment, but can be done now in a DIY way with relatively small, simple and cheap sensors. This opens up new opportunities for more people to gather interesting data themselves. In this project, we too used such widely available technology to show/explore what novel observations we could unlock in our ordinary life.

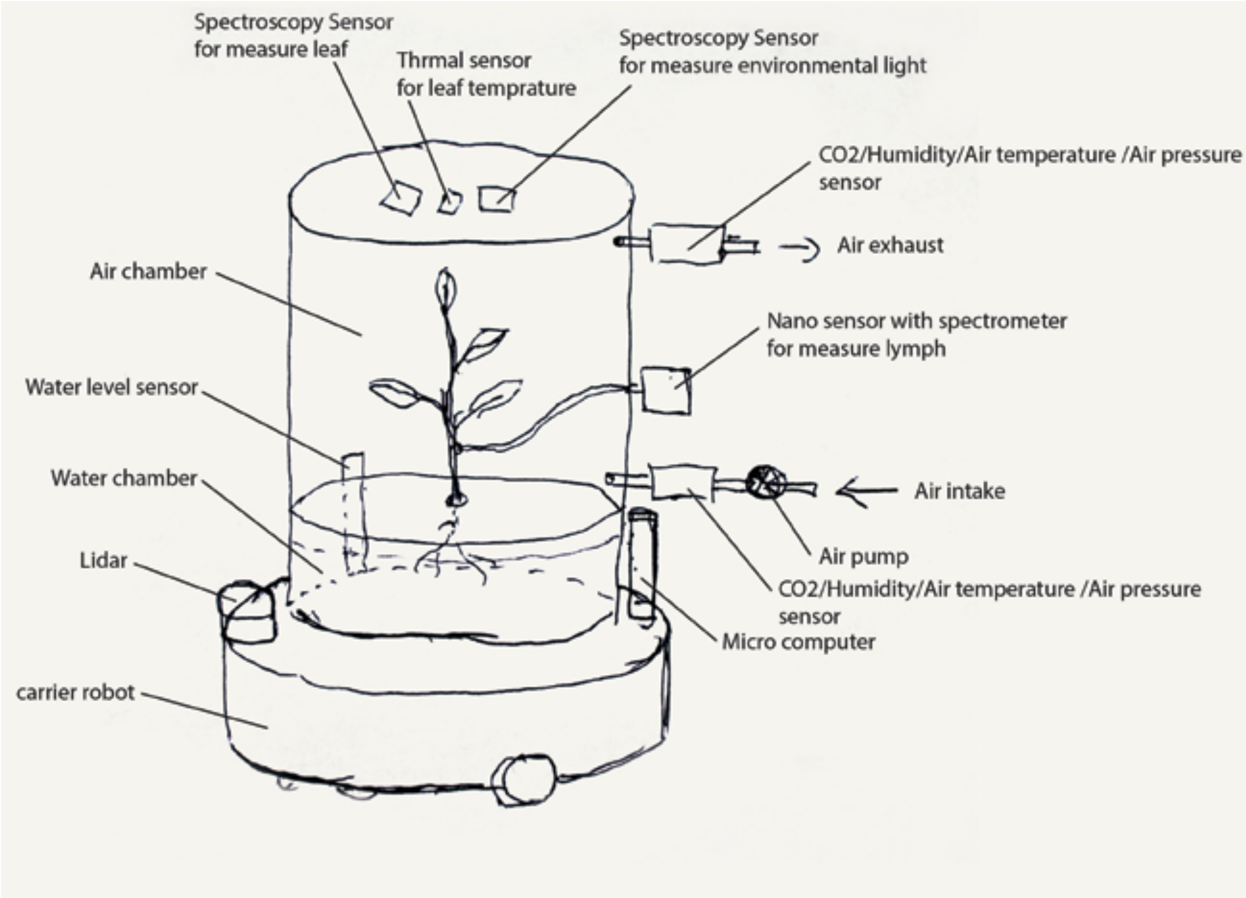
Chamber

To measure the plant's activity, we designed a two-room chamber system. The chamber at the bottom of the construction is filled with water. We chose this hydroponic method to minimise gas emission from biota in the soil and because it gave us the possibility to measure the plant's water consumption. This was also decided due to a strong concern for the aesthetic perspective of the plant's housing.

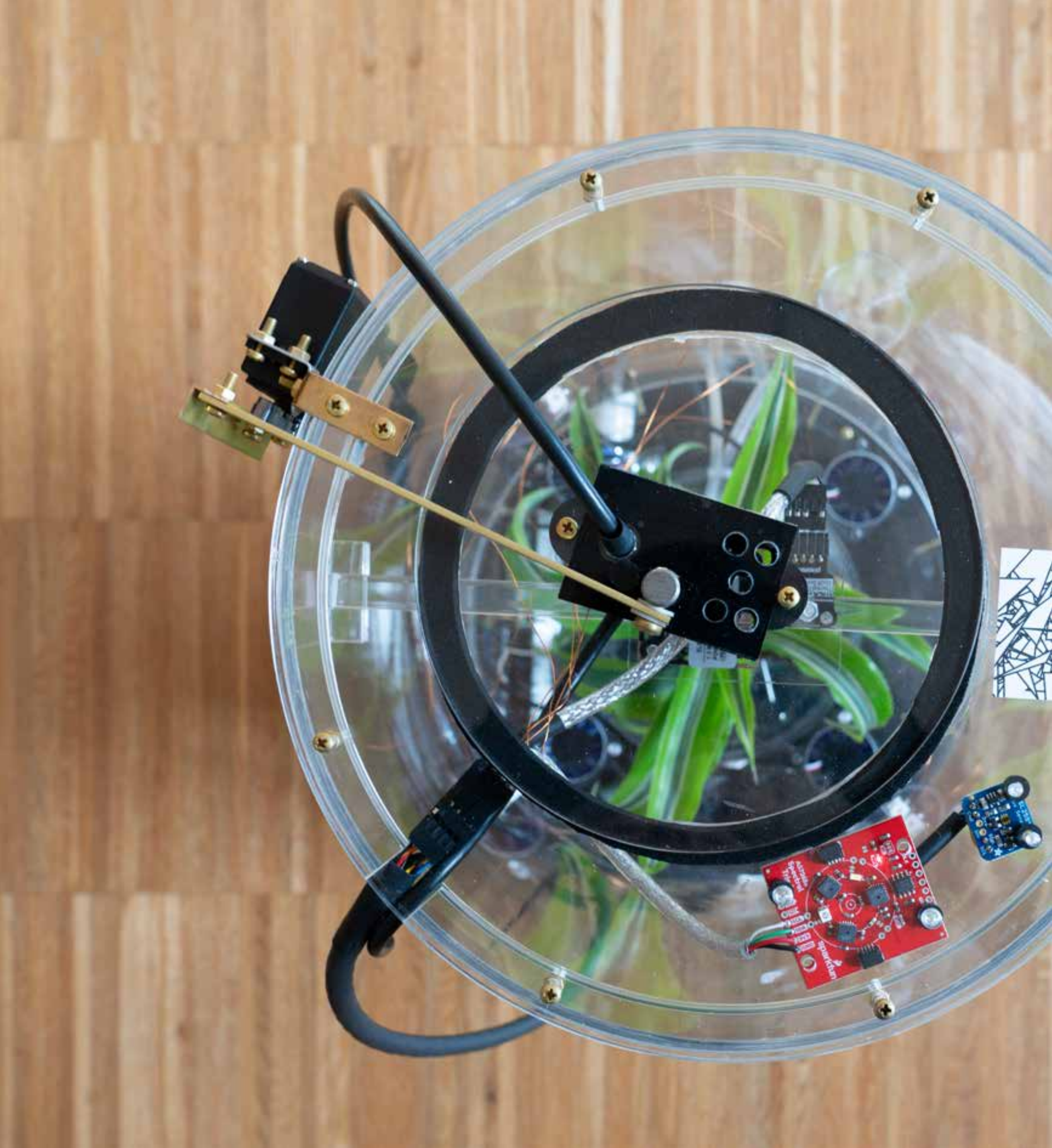
Above the water chamber, an isolated chamber for the plant was prepared. This chamber was equipped with one directional air-flow control system (fan). At the exit of the airflow, a sensor measuring CO2/humidity/ temperature was positioned. With this construction, we acquired the ability to measure the plant's basic activity. The chamber was also equipped with an automatic lid that minimises the stress for plants at night time[6].





horaica,
Resonances III Datami
Akitoshi Honda
materials,
2019



horaica,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Installation view
Photo Akitoshi Honda

Plant selection

Data on the behaviour of plants is totally missing. It was thus not possible to choose particular plant species based on this behavioural data. As a result, the plants were chosen on their aptness for hydroponic cultivation. The plant species considered and used were: Schefflera arboricola, Euphorbia milli, and Fragrant dracaena.

Processing data

All sensors are controlled and fetch data to Teensy micro-controllers. The collected data are sent and pre-processed in a microcomputer (Raspberry Pi Zero), then transmitted to an online databank where they are processed to determine the plant's "emotion".

AR application

The data is fetched from an online data server to an AR application custom-made for this project, for either iOS or Android devices. Viewers/visitors can use this application to 'see' the plant's spatial activity.

At the beginning, we discussed with Andrea Valsesia from the nanobiotechnology laboratory other possible projects and different types of plants-sensing methods by means of nano-technology.

In the course of several visits to the JRC in Ispra, Andrea and me finally developed a nano-sensor which reacts to particles, and especially those of a size of sucrose, with a nanosize gold structure.

Diana Rembges supported this project with her special knowledge in botanical science. We decided several important factors for the project, such as using hydroculture instead of soil culture to minimise CO2 consumption/release from bacteria, after extended discussions with her. She played an important role in the question of how to build a chamber so we could measure the CO2 consumption of plants, as well as measuring leaf area index, and leaf temperature. She also helped us in the selection of the plants.

Nanoplasmonics for smart plant sensing

Andrea Valsesia

Despite its very fancy name, nanotechnology is a very antique discipline. Nanotechnology was in fact already being used by medieval glass-masters to colour the windows of gothic cathedrals. They realised that by mixing powders (they did not know that these were nanoparticles) of different metals, it was possible to create glasses with different colours, depending on the nature of light exposure.

This was the birth of 'the plasmonic effects', which result from the interactions of light and metallic nanoparticles.

This so-called 'plasmonic effect' was demonstrated many centuries later, in the early 1900's, by German physicist Gustav Mie. Mie provided a theoretical demonstration of plasmonic resonance absorption of gold colloids using Maxwell's electromagnetic theory. He observed some sharp different absorption bands depending on the material and on the nanoparticle size, which explained the change in colour that occurs as the size of the colloid nanoparticles increases from 20 to 1600 nm.

After a few decades, bio-molecular researchers developed the idea of using the plasmonic effect to detect small molecules. In fact, the spectral position of the absorption band depends on the refractive index of the material surrounding the nanoparticles. When small molecules bind the nanoparticles, they can be easily detected by the shift of the absorption band (i.e. a change in the colour of the colloidal dispersion).

Here we use a nanostructured surface of gold with a regular array of cavities, which physically behave exactly as gold nanoparticles surrounded by a dielectric medium. We are able to fabricate billions of nanocavities within one mm square. Monitoring the light absorption band enables us to detect the refractive index of the sample, with an extremely high sensitivity and precision.

We call it 'nanoplasmonic chip'.

In our set-up, the concentration of sugars and minerals in the sap of a plant is directly determined by monitoring its refractive index. The higher the refractive index, the richer is the sap in contact with the chip. The nanoplasmonic chip is coupled with a microfluidics channel, a minuscule tube, which contains less than 1 microliter of sap. The measurement of the sap quality becomes routinely accessible and less invasive for the plant, since a small amount of sap can be spilled out by a capillary tube, without causing major injuries.

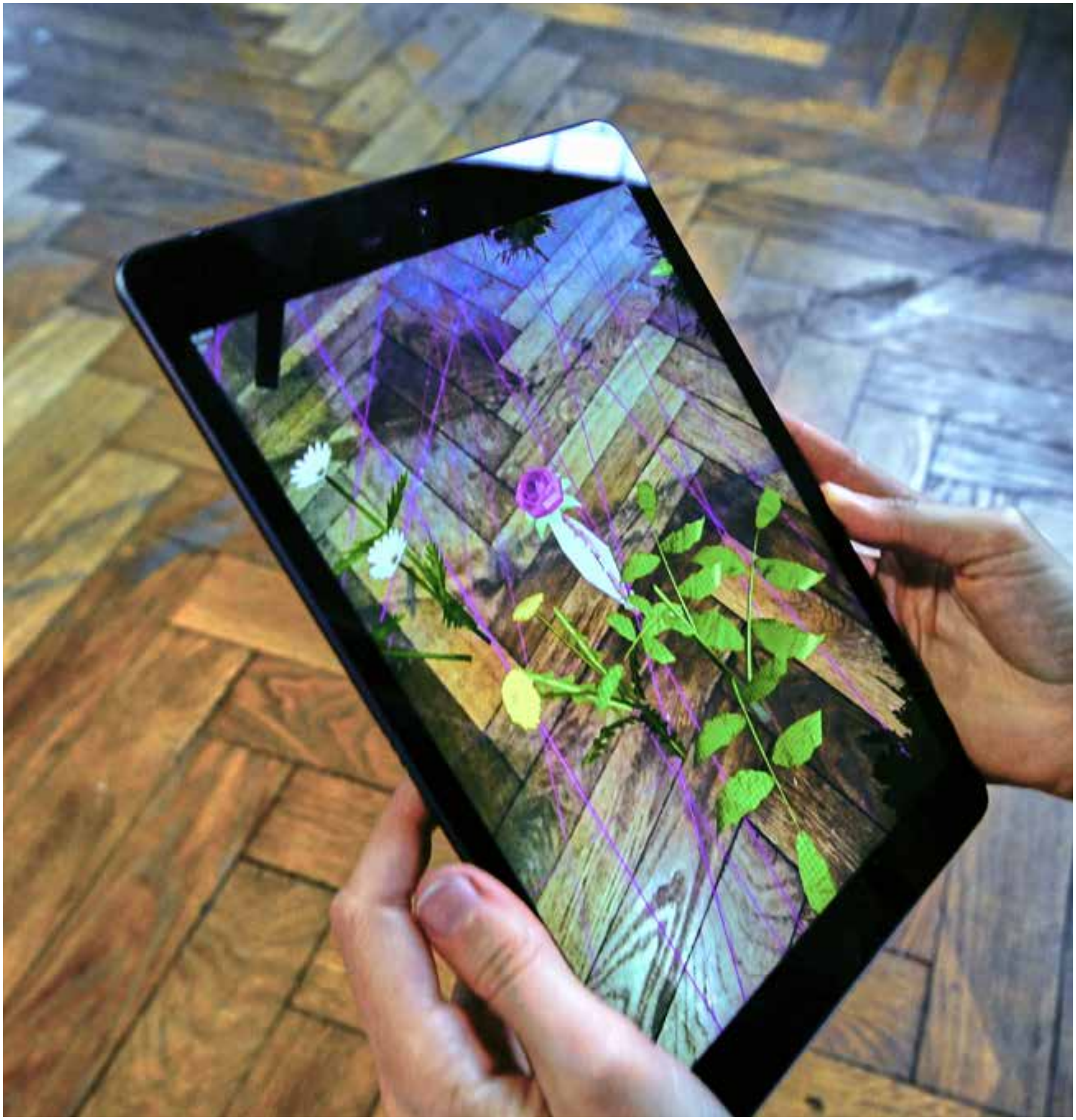
This is a good example of how micro- and nanotechnologies bring a decisive advantage with respect to standard technologies, creating the opportunity to build miniaturised and smart sensors, wearable by living beings.

Notes

1. It is a custom to plant pine trees in the precincts of shrines and temples in Japan. Omura, Hiroshi, "Trees, Forests and Religion in Japan" in Mountain Research and Development 24[2], May 1 [2004]: 179-182 https://doi.org/10.1659/0276-4741[2004]024[0179:TFARIJ]2.0.CO;2.
2. For an article on the film, see e.g. https://www.artsy.net/article/artsy-editorial-pioneering-artist-harnessed-science-communicate-plants. Excerpts that were not inserted in the final movie can be seen on YouTube, at https://www.youtube.com/watch?v=OR4ZNV3hU7o.
3. This is known as hydroponics.
4. Leaf area index [LAI], the amount of leaf area per unit ground area, is one of the dominant factors controlling plant productivity [https://onlineli- brary.wiley.com/doi/full/10.1111/geb.12133].
5. Microelectromechanical systems [MEMS] is the technology of microscopic devices, particularly those with moving parts.
6. See C. Breuninger, R. Oswald, J. Kesselmeier, and F. X. Meixner, "The dynamic chamber method: trace gas exchange fluxes [NO, NO2, O3] between plants and the atmosphere in the laboratory and in the field", In: *Atmos. Meas. Tech.*, 5, 955-989, 2012, https://doi.org/10.5194/amt-5-955-2012

horaica,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
On the next page:
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Installation views and details
Photos Cristina Fiordimela, Akitoshi Honda

H



horaica,
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 - 19 January 2020
Details
Photos Riccardo Pareggiani,
Akitoshi Honda

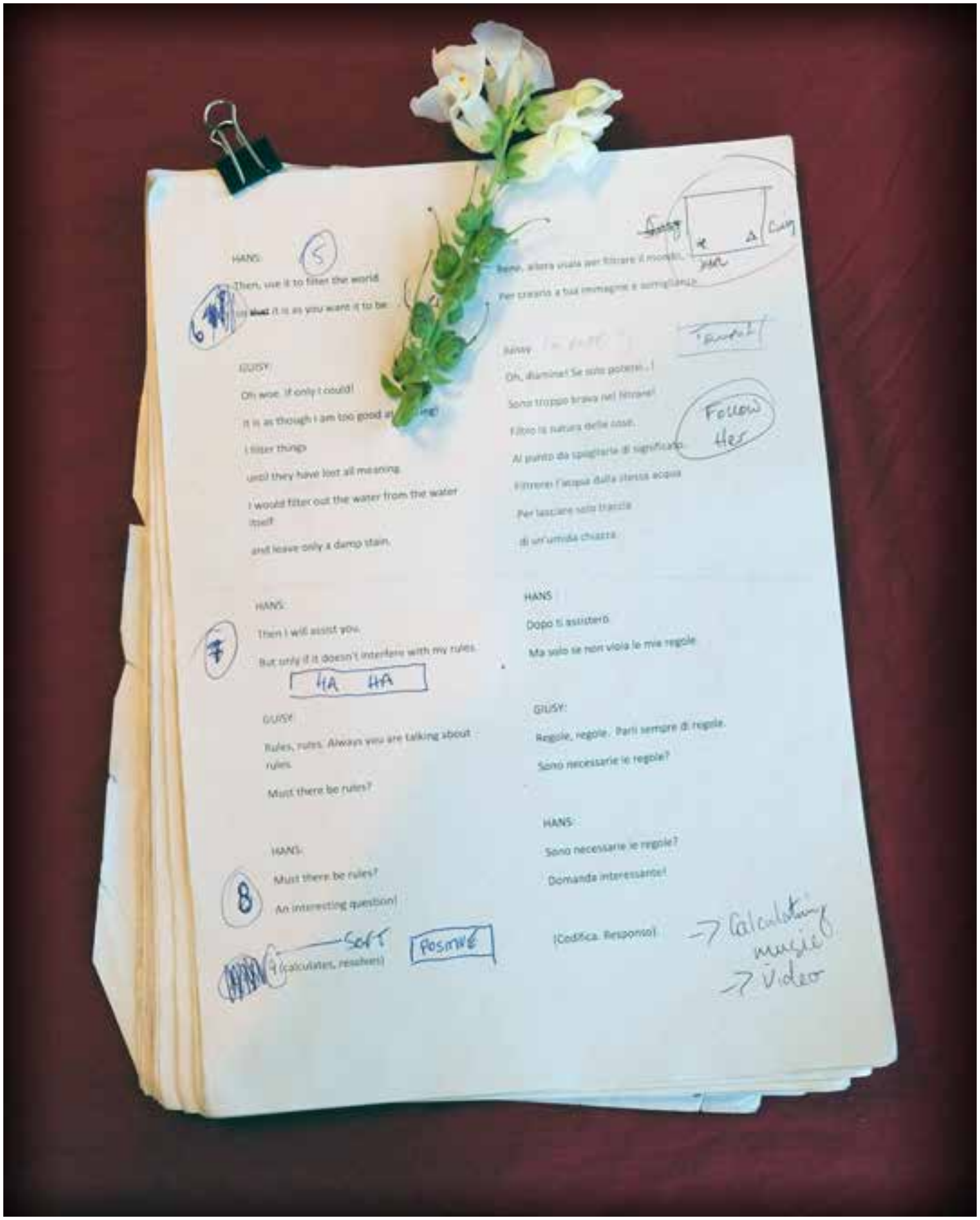
My Data and Me: una storia d’amore

Artists
Richard Pettifer, Director/Libretto
Prasqual, Composer

Scientists
Vasiliki Charisi
Marius Miron
Emilia Gomez Gutierrez
Marnia Escobar Planas
Nicole Dewandre
Nikolaos Stilianakis

Collaborators
Francesca Martini, Soprano
Electronic ID [Cologne], Ensemble
Cristina Lelli, Designer
Songul Tolan, Script Advisor

My Data and Me: una storia d'amore,
SciArt Datami project, 2019
Opera



My Data and Me: una storia d'amore,
Resonances III Datami
Exhibition BozarLab, Brussels
10 December 2019 – 19 January 2020
Richard Pettifer,
Notes of video *A love Story Me and my Data*
Photo Peter Reid

Program Note

When I first emailed Prasqual a one-liner saying, “did you ever compose for opera?” and he replied with the even briefer, “I have composed five so far”, a series of coincidences were catalysed, evolving into the work you see today: the beginnings of an opera in two acts on the theme of Love.

Yet, as in love, nothing in opera happens by chance. The characters of the opera stage are trapped inside pre-determined systems of production, exhibition, and distribution, the same structures that render opera the least accessible and least flexible of the art forms, even as it is the most predictable. Likewise, the giant structures required to create opera ensure their historical eurocentrism, conservative gender politics, and racisms – think of the depiction of Romani women in *Carmen*, or the orientalism of *Madama Butterfly*. These continue largely unchallenged, beyond the occasional provocative flare-ups in identity politics.

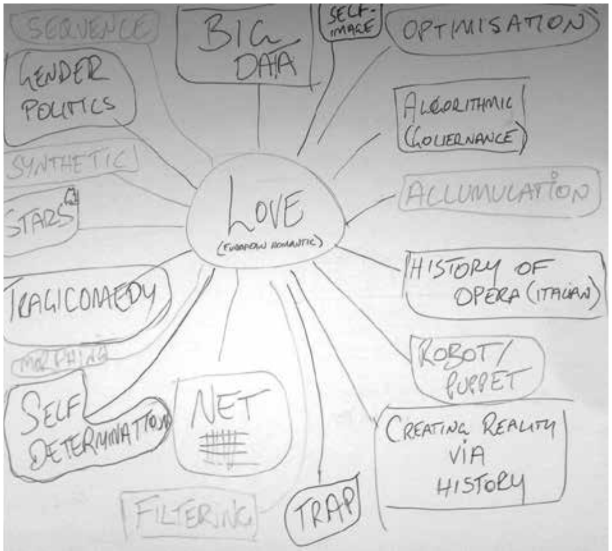
As a result, these same racisms, misogynies, and other oppressions inherent to European culture, repeat themselves – this time in the cloud.

Working now in a frontier of thought and experimentation, we are not necessarily constricted by the old ways of doing things. However, interest in change requires some will and courage, to be bold and take risks, to develop our consciousness by educating each other, and to put aside our fears of offending the often invisible gatekeepers of both science and culture.

With this opera we have created an ambitious, direct kernel of an epic *Gesamtkunstwerk*[1] with comparatively little resources, little time, and a lot of willpower. We are very grateful to the European Commission’s *HUMAINT* program in Seville, and particularly to Script Advisor Songül Tolan, our chief contact Emilia Gómez Gutiérrez, robot-arms-builders and advisors Miguel Vázquez-Prada Baillet and Marina Escobar Planas, and advisors Vicky Charisi, Nikolaos Stilianakis, Nicole Dewandre and Marius Miron for taking the leap of faith on this new collaboration. Our two weeks in Seville on residency were marked by a mixture of concentration and pleasure that bleeds into the project, with flamenco and robots alike leaving their own distinct footprints in our minds.

The sheer amount of “firsts” in the work is testimony to the belief shown in human beings within our extensive and ad-hoc community of artists and experts surrounding the project. On top of being my own first opera, this is the first opera for Resonances, first opera co-produced by the European Commission’s SciArt program, and among only a few operas that are constructed outside of a well-oiled and protected opera world. This represents a remarkable opportunity to make something truly new: an art object of world-changing transgressive capability.

Those firsts do not, interestingly, include the first opera to feature a robot. However, they probably do include the employment of a “shabby-epic” principle of design: that the robot *Jabel* would be constructed not to impress an audience with uncanny valley or steampunk aesthetics, but as though it had been assembled by human or even children’s hands, in an amateur manner, almost from the discards of digital material. In this way, we draw attention to the uncomfortable ideology of technology, and that the screens do not appear by magic but are, like Big Data itself,



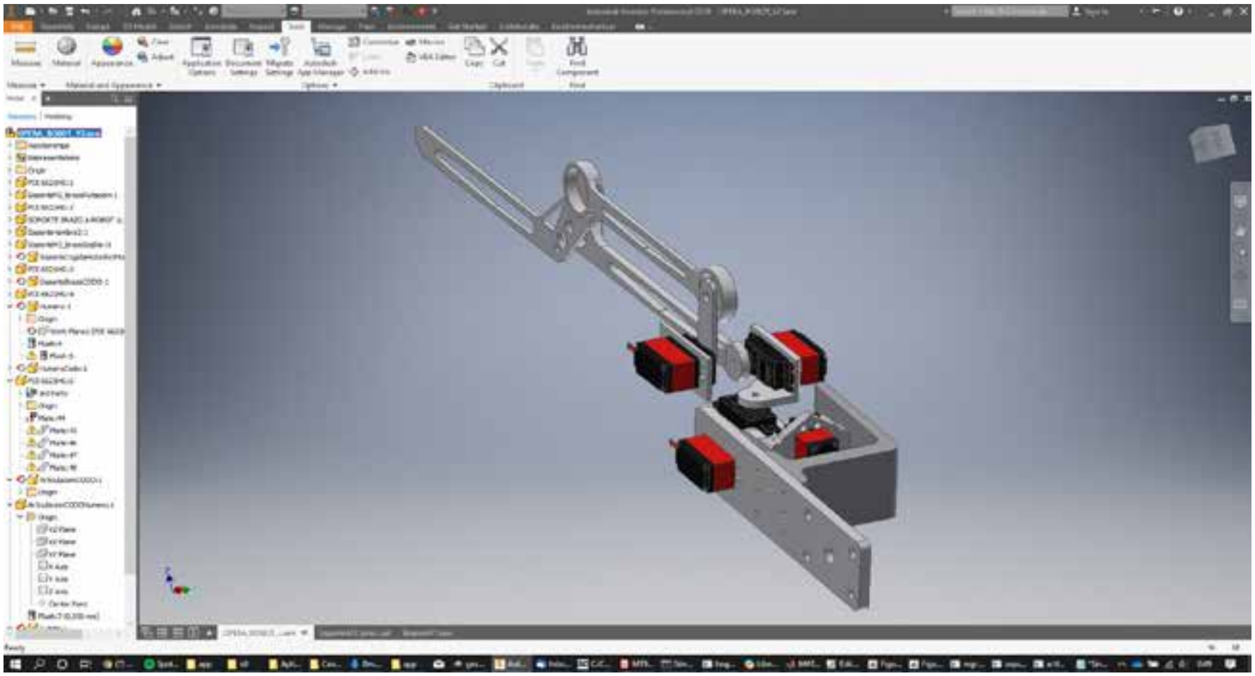
My Data and Me: una storia d'amore,
Resonances III Datami
Richard Pettifer,
materials, 2019

determined by economic, corporate, social and political interactions, and with their manufacture at the hands of individuals on a production line.

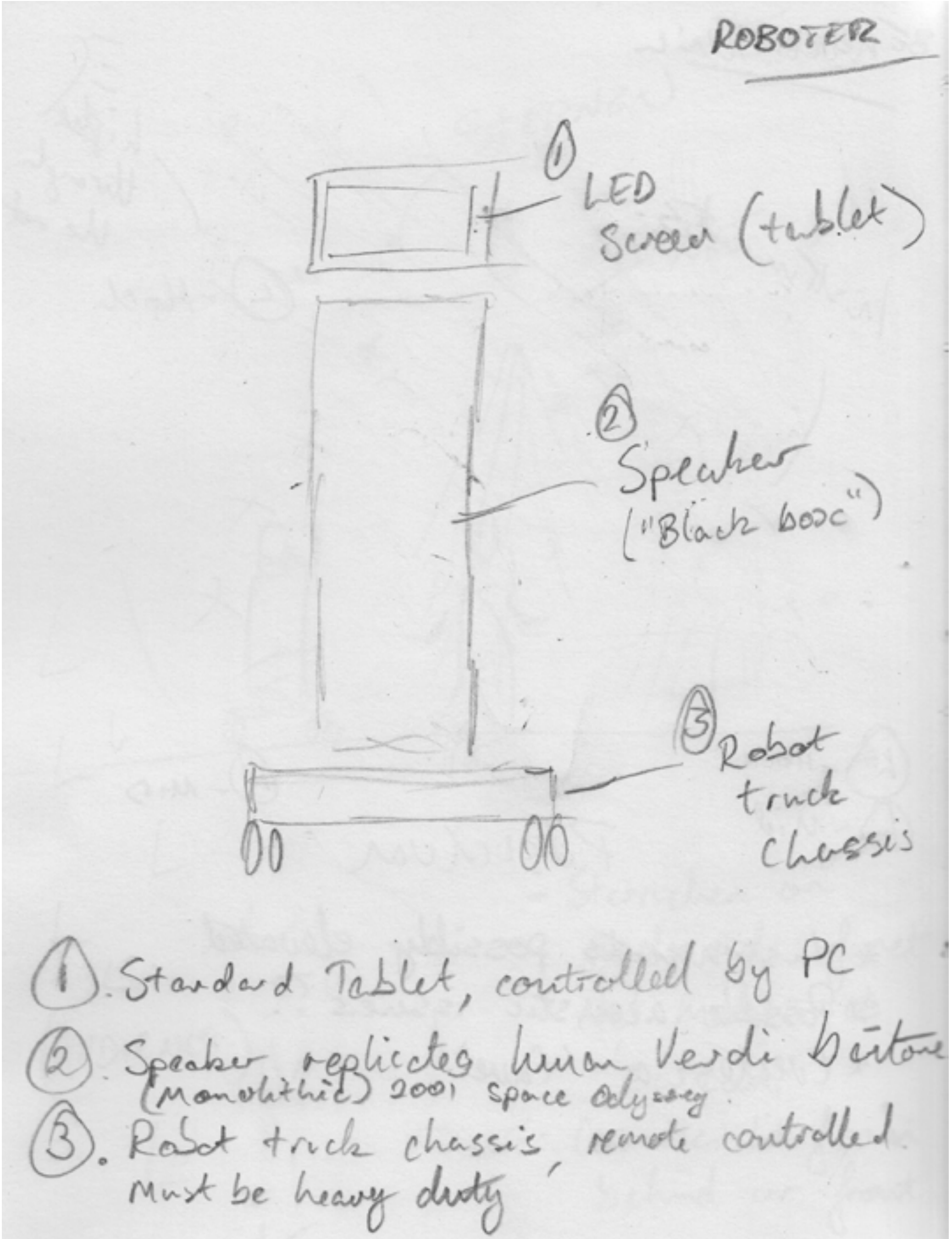
The return to a materialist sensibility is my proposal for both Opera and Big Data in this moment – that its effectiveness radically hinges on its capacity to connect with the non-digital lived reality of the 21st century. When looked at through this lens and without the hype, the possibilities of the future may at first sight underwhelm, lacking in the neon-blue visions that permeate the aesthetics of both science-fiction and technology industries. But when we look closer, that lived reality, messy and improvised though it is, remains unavoidably, disgustingly, corruptibly human – in my view, that is something of which we can be proud, and which brings with it the significant responsibilities of governance – if we are not too busy being lost in an escape to fantasy worlds.

Finally, I would like to thank my most faithful and generous friends: the soprano Francesca Martini, whose generosity and patience were key early in the project. Designer Cristina Lelli, who managed to take brilliant stabs in the dark largely poor of time. Translator Giuseppa Prestigiacomo, who emphatically met the deadlines. Robot platform constructer Frank Fietzek who gave movement to an idea. And finally Cologne-based producer Caroline Skibinski, who jumped in and gave administrative form to the chaotic galaxy of collaboration. Women's authorship and voices penetrate every detail of the work (even as I accept responsibility for the malfunctions). Then there is Prasqual himself, who has been my greatest guide, with is persistence and relaxed temperament.

This is a project headed for the stars. May you see in it what we saw those early days: a constellation of possibility in each other, and therefore in reality itself.



My Data and Me: una storia d'amore,
Resonances III Datami
Richard Pettifer,
materials, 2019



My Data and Me: una storia d'amore,
Resonances III Datami
Richard Pettifer,
materials, 2019

Synopsis

Deep underground in the future, a young woman, Elfreda, lives alone with her artificial intelligence, Hans (*Tutto è bello nel mondo*). They have created a content fictional existence, complete with dinner-table, television, and medical needs. They attempt to keep Elfreda alive using the simulation skills and Big Data predictive abilities of Hans (*Sono un artista di dati*).

They have discovered that Elfreda has a biological need for human drama, and because of this, they have created a romantic tragedy (a play-within-a-play), which they play each night after pizza. Hans (playing the role of the romantic suitor Klaus), arrives one night at the villa of Maria (played by Elfreda), and sings to her from beneath the balcony (*Quando tornerà l'amore*?). Maria agrees to marry him, but on one condition, that she is able to first tell her other suitor, James, a French nobleman who thinks they will be married, over a dinner at the local pizzeria (*Innanzitutto, una pizza)*.

At pizza, before Maria can reveal her decision to marry Klaus, James explains that he is dying from an anxiety-related condition. He repeats his belief that they will marry before he dies. Not wanting to cause his death, Maria agrees, and accepts his invitation to the League Party annual dance the next evening (*Non posso spezzargli il cuore, non sono un mostro*). At the League Party dance, Klaus explains that he will look out for Maria and publicly dance with her to demonstrate their coming marriage (*La farò mia*). Upon seeing her dancing with James, Klaus flies into a jealous rage, and declares his intent to kill his opponent (*Sono il più grande di tutti*). Maria watches as the two struggle, with James the eventual victor. She laments her loss of two suitors (*Da due, sono diventato niente*). James returns, and takes her back to make love in Maria's villa.

During the love scene, Hans malfunctions. He explains to Elfreda that he can no longer predict her behaviour using his predictive algorithms, because he has lost access due to recent weather events on the earth's crust. Without being able to predict her behaviour, he can no longer guarantee that he can protect her psychologically or physically (*Sono assoluta incertezza*). Elfreda leaves, distraught. Hans laments to the audience the real reason he can no longer predict her behaviour: that he is no longer sure whether it is Maria or Elfreda he is speaking with (*Sei vera, mia Maria*?). His probability calculations have suggested that Elfreda's illusion of perpetual continuity must be shattered to bring her back to reality, but that there is also a high risk of her death.

Returning as Maria, Elfreda offers Hans an ultimatum: protect her, or she will kill herself. Confused, Hans ex-plains that he is programmed to prevent her from self-harm, but that he can no longer predict her behaviour (*Non c´é futuro, adesso*). Revealing a dagger, Maria asks Hans to close his eyes. Hans does so, only for Maria to charge at him. At the last moment, Hans paralyses her with a laser.

Sitting again at the dining table happily, the two sing a final duet (*Tutto è di nuovo prevedibile*) only for Maria to reveal a second dagger and for Hans to paralyse her once more before the curtain falls.

Note on Robot Design and Construction

It is proposed that, in collaboration with JRC scientists, a robot be constructed, which can sing the part of Hans. This proposal may seem daunting – however, a "robot" could be little more than a jukebox, playing the tracks at the appropriate moment, possibly with a mechanism to move it around the stage so that blocking of the director may be retained. Given the extensive training offered to an opera singer, the combination of singer and robot also asks questions about whether a robot's singing is actually better than a human's. (For example, the robot can effectively replicate performances, whereas for a human this is difficult).

We would consider creating the role of Hans around the limitations of what a robot can achieve as an opera singer, and working in collaboration with a robotics expert to ask these questions. What is a robot? What is an opera singer? What is the difference?

Precedents and influences

Kubrick, 2001: *A Space Odyssey* (USA, 1968)
Lauri Wylie, *Dinner for One* (UK/DE, 1963)
Verdi, *La Traviata* (ITA, 1853)
Daft Punk, *Human After All* (FRA, 2007)
Offenbach, *The Tales of Hoffman* (FRA, 1881)
Bretan, *Golem* (ROM, 1923)
Rameau, *Pigmalion* (FRA, 1748)
Besson, *The Fifth Element* (USA, 1997)
Vangelis, *Blade Runner* (USA, 1982)
Director Oriza Hirata and roboticist Hiroshi Ishiguro,
Kafka's Metamorphosis (JAP, 2014)

Notes

1. Universal Artwork

Pictures on this page
and on the next page:
My Data and Me: una storia d'amore,
Resonances III Datami
Festival JRC Ispra site
15 October-8 November 2019
Rehearsals and Performance,
Photos Richard Pettifer Archive

She is gone.
With her, goes my heart.

I am a Data Artist

I am a data artist
I accumulate infinite possibilities
More than predictable outcomes
(according to casual laws).

I am a data artist
I control creation
And let destruction free,
Tormenting Juissy with dreams of the sky
I make her false flowers,
And she smells them, with love.

Data is my clay and canvas.
The possibilities are big
I sculpt nature with my hands
And create our own reality.

I am a data artist
I am history's actor
And you, all of you, will study what I do.

Se ne è andata,
Con lei, va via il mio cuore!

Sono un artista dei dati

Sono un artista dei dati
Colleziono infinite possibilità
Molto di più dei risultati prevedibili
(In accordo con le leggi del caso)

Sono un artista dei dati
Controllo la creazione
E lascio libera la distruzione,
Tormentando Giusy le lascio sognare il cielo
Le regalo fiori finti,
E lei li annusa, con amore.

I dati sono la mia argilla e la mia tela.
Le possibilità sono ampie
Modello la natura con le mie mani
E creo la nostra realtà

Sono un artista dei dati
Sono un attore della storia
E voi, tutti voi, studierete cosa faccio.

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Online Sources

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Epilogue

"You are muted!"

Jutta Thielen-del Pozo

With the ending of the Resonances III Datami exhibition at the Bozar on 20 January 2020, the third Resonances cycle ended. Several downstream events with selected art works to be exhibited were planned, notably showings during the Milan Digital Week 2020 (26-29th May) and the EuroScience Open Forum (ESOF) in Trieste in July 2020.

However, events were overtaken by the outbreak of the SARS-CoV-2 pandemic and full or partial lockdowns, physical distance rules, restrictions on the number of participants in meetings suddenly dominated our lives. From one day to another, planning ahead became difficult, nay impossible, and our interactions became limited to online meetings. We started seeing the world through a screen, scrambling for solutions to connect, and the sentence "you are muted" will for sure stick to our memories for a long time after the pandemic.

The work of the European Commission on AI, that had started in 2018, became urgent and the EC sped up the release of guidelines and prepared regulations for AI-enabled technologies. Importantly, policy options were set out to promote trustworthy AI and secure development of AI-enabled technologies. The possibilities of data collections on large scale and bringing together new data sources is adding a complexity to big data which both requires and drives innovative approaches. Data is the bread and butter of machine learning algorithms and AI and leaves us with many challenges yet to tackle.

For the EC the protection of both the individual and society as a whole plays a foundational role in scaling up the development and deployment of AI across Europe – in the public as well as the private sector. Building trust into the rollout of AI solutions that are in line with the European values and ethical standards are fundamental elements of the European policies. With the launch of the AI Act in 2021, Europe ensured that we can trust on AI solutions designed to assist humans in solving problems and performing tasks at the highest ethical standards.

Early on, since 2018, the JRC positioned itself in the forefront of AI at the EC level. The Datami SciArt project, which tackled the social impact and importance of AI, Big Data and the Digital Transformation, the JRCs Flagship Report on AI and the HUMAINT project at the JRCs Centre for Advanced Studies were among the first steps at EC level to ensure evidence based, Trustwrothy AI in Europe.

The pandemic and its severe impact on all aspects of our lives clearly illustrated the relevance and importance of the DATAMI concept!

Resonances III Datami
Milano Digital Week online edition
26-29 May 2020, Flyer
Coordination by Angela Cardinali
Graphic Design by Cristina Fiordimela

Blumine Featuring Joint Research Centre Resonances III Datami was selected from 35 projects which were presented in the book, Blueprint. The book presented transformative and urgent cultural practices, curated by cheFare, Polo del'900 and Simone Arcagni. The book was published in 2020, hoping to liven the debate on ways in which culture had transformed during the lockdown months. The online event, Datami for the Milan Digital Week 2020 is referred to on page 60-61, as part of the "Digital Culture" category and in the theme "Art, digital art and science", with the following reasoning:
"The visual framing brought about by the reduction of the screen due to the pandemic has highlighted the unease of bodies-exiled by digital techniques of 'sharing', by sidelining knowledge practices of commoning which struggled to reach embodiment. The augmented-bridge datami-transformed to a city seems to us an experimental experience from which to begin an alliance between image and intellect, maintaining tension between bodies. https://che-fare.com/progetto/blueprint-pratiche-culturali-trasformative-urgenti-polo-del-900-simone-arcagni/"

Resonances III Datami Events

Milano Digital Week ,
Palazo Giureconsulti, Milano
13-17 March 2019

Festival JRC Ispra
15 October-8 November 2019

Exhibtion BozarLab, Brussels
10 December 2019 - 19 January 2020

Milano Digital Week Online Edition
26-29 May 2020

Organised by the SciArt programme of the Joint Research Centre of the European Commission

From DATAMI to SCIAME
SciArt Heritage Museum Expanded at JRC Ispra Site
“Museums as Cultural Hubs: The Future of Tradition”
Cristina Fiordimela and Freddy Paul Grunert with Adriaan Eeckels
April 2019

The vision of a new 'kind' of museum for scientific instruments and spaces within the Joint Research Centre in Ispra unfolds during the study of the exhibition of the Datami works. Datami is a mixture of meet-ups/dialogues/laboratory/residences/festival/exhibition: an 'expository' hybrid activated by what we called opera, plural of the latin opus: the common effort by artists and scientist to conceive and realise works blending art and science in intricate ways, sharing the same space-time in the JRC Ispra site.

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Within this useful/campus-museum, we want to draw the attention to the unanticipated disclosure of a hidden/missed immaterial heritage that emerged from these two years of activity on the Ispra campus. This has led to the idea of realising an active museum conversion: the wealth of laboratories, itineraries, archives that connect different buildings, also abandoned ones, such as nuclear reactors, complete with closed laboratories, specific tools, that still have a historical significance, instruments and archival records of different types (images/text/experimental, probabilistic data).

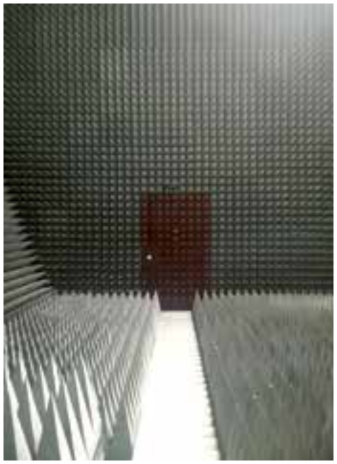
We call this museum activated, because the 'incorrect' use of the places and obsolete instruments are reactivated by this artistic incursion of the SciArt opera that activates a narrative media on the passage of the nuclear to post-nuclear society, up to the illimited languagesof AI.

We call this activated museum SCIAME – Science Heritage Art Museum Expanded. Beyond the opposition tradition/future it proposes the fluid interface of the present as a threshold of blue print of experienced (embedded) knowledge: History, language, values and, inevitably, a 'culture-bond nature' tying up all viewpoints, jointly create a new vision on what we could call 'real curved space'.

Logo of Datami-Itineraries for a young public at JRC Ispra Site, by Cristina Fiordimela, inspired by the Latestei frog, a native species of the small lake belowthe European Commission Atmospheric Observatory's tower at the JRC Ispra Site.
The frog Latestei is characterised by the red colour and the black dots on the skin.

On July 10, 2019 at 11.40 during the Festival in/Visible Cities P. L. Capucci organized the Conference "Arti e scienze nell'era post accademica" [Art and Science in the post- academic era] at the theatre Miela in Gradisca and invited A. Eeckels to introduce the JRC's institutional SciArt program and C.Fiordimela with F. P. Grunert to present their systemic SciArt approach to Datami. During the presentation by Chiara Perrini with the association Quarantasettezeroquattro the organizers of the Festival wished to expose Datami in 2020, thereafter canceled due to the Covid.

Courtyard of Torriani Palace, Gradisca.
Photo Cristina Fiordimela

Sequence of images for the project
"From DATAMI to SCIAME.SciArt Heritage
Museum Expanded at JRC Ispra Site".
Photos Cristina Fiordimela Archive

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Fonts
Akzidenz-Grotesk BQ, Century Gotic and Simplon Mono

Paper
Fedrigoni Arena Extra White Smooth 120 g (interior)
Fedrigoni Arena Extra White Smooth 350 g (cover)

Printed in Italy by
Artestampa, Varese

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Distribution

Luxembourg: Publications Office
of the European Union, 2024

Printed in the European Union - Italy

How to cite this report: Eeckels, A., Fiordimela, C., Paul Grunert, F., Thielen-del Pozo, J. (editors), *Resonances III: Datami*, Publications Office of the European Union, Luxembourg, 2024, doi:10.2760/7364
JRC118431

	Support/Volume	ISBN	DOI	Catalogue Number
EN BOOK	PRINTED/Volume_01	978-92-76-10370-7	10.2760/498106	KJ-02-19-899-EN-C
EN PDF	PDF/Volume_01	978-92-76-10369-1	10.2760/7364	KJ-02-19-899-EN-N

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In the third instalment of the Resonances Festival, JRC scientists and EC policymakers worked arm in arm with twenty-three artists on the theme of Big Data, Artificial Intelligence and Digital Transformation. What are those Big Data that have erupted in our lives? How do they change our habits, our social relations, our work and even our democracies?

These are some of the many questions discussed between artists, philosophers, policy-makers and a diverse group of scientists. Working together on the edges of their respective practices, they reflect the variety of sciences practised at the JRC in its effort to deliver sound and fact-based evidence to European policymakers. Shining additional light on how Big Data are everywhere, in geology and economy, in meteorology and biology, in structural engineering as well as in demography and even our personal daily lives. In this exercise, renowned cultural writers such as Lev Manovich and Ignazio Licata also lean in to accompany these experiments.

Crossing boundaries and finding differences and similarities, the works the participants to the Resonances Initiative produced together reflect the uncertainties of disclosing new territories. Some tend more towards art, some more towards science, but each pushes the borders of science and art closer to each other, successfully stepping into the realm of SciArt, one of the most intriguing new disciplines of the unfolding century.

Central to their work was the new concept of datami, where new data meet the old concept of tatami: versatile, used for rest, repose, and concentration, unit of measure for building. The datami invokes a much-needed unit of measure for our multifarious new identities. Digital meets the analogue, identities merge and online becomes onlife. New concepts swirling in our lives are demanding new practices. It is a research. It is a collective journey. It is also an exercise in democracy: what do we want from these Big Data?

The results of this journey are laid out in the Resonances III Datami Exhibition and in this book.

It is a journey into our emerging digital world.

Magda Stanova

THE MAKING OF DATAMI
(a draft* diary)

* In honor of the "Draft Agenda" of the Resonances III festival, which was never replaced by a final agenda.

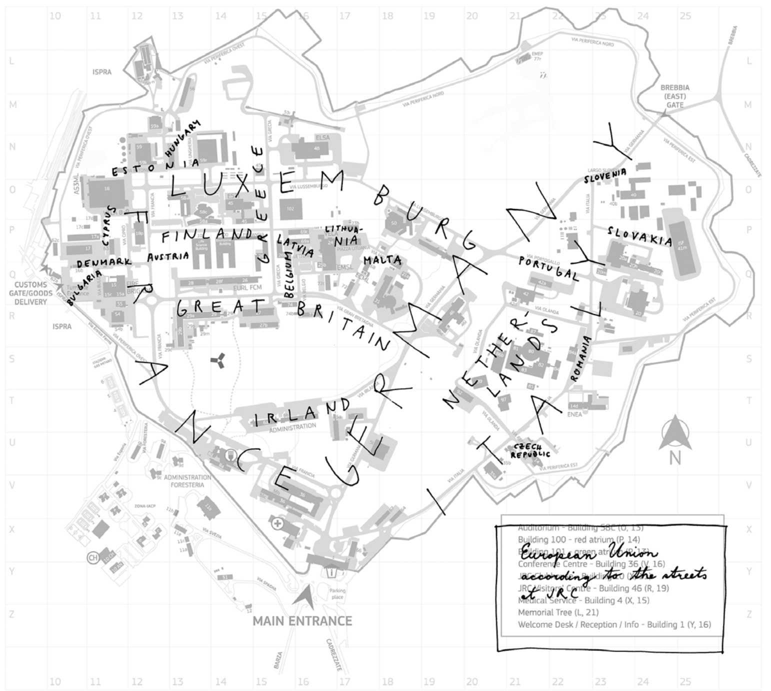
1
JRC

When you're entering the Joint Research Centre (JRC) in Ispra, you're leaving Italy and entering the EU, although Italy is also in the EU, but inside the JRC you feel like you're really in the EU. The flags of the EU are on everything, including garbage cans and toilet.

It also looks here differently than in Italy — — there are no palm trees, and buildings look very diffrently too (e.g., windows have no blinds unlike everywhere outside the JRC). It even looks here a bit like in Las Vegas:

When you're arriving, it seems like you're entering a kind of a zoo, because the JRC is a park-like area with a tall fence around it and inside are pavilions with different types of scientists. (I hope that scientists haven't got offended by this metaphore, but they also talk about a "particle zoo", and who knows how particles feel about that.)

The streets in the JRC are named according to the EU countries, but the position of the streets doesn't relate to the geography of the EU. If we made a map of EU according to the streets in the JRC, it would look like this:



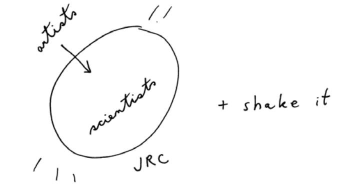
2
ARTISTS AND SCIENTISTS

Art and science come from the same source — — creativity, but these fields got separated in the course of history.

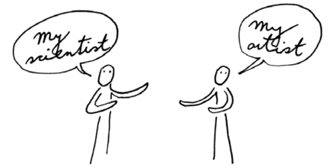
CREATIVITY

ART SCIENCE

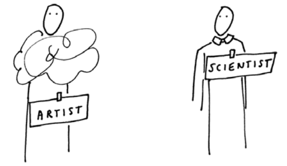
The aim of the SciArt project is to bring these fields back together. So they put artists and scientists together for five days at the Summer School.



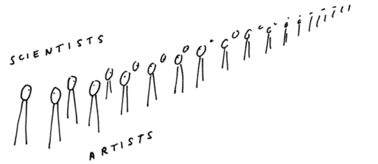
And what came out are these artist-scientist couples:



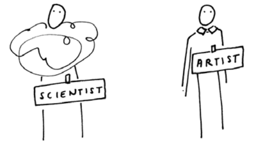
But as one of the participants pointed out, in some way, the division between these two fields got even more reinforced by this — — people were clearly divided and labelled as either "a scientist" or "an artist".



So maybe in the next editions of SciArt project, it would be better if, instead of a speed- -dating session,



there was a carnival, where you can dress either as a scientist or as an artist.



Another problem by art-science collaborations is a common assumption that

ART COULD BRING SCIENCE CLOSER TO PEOPLE

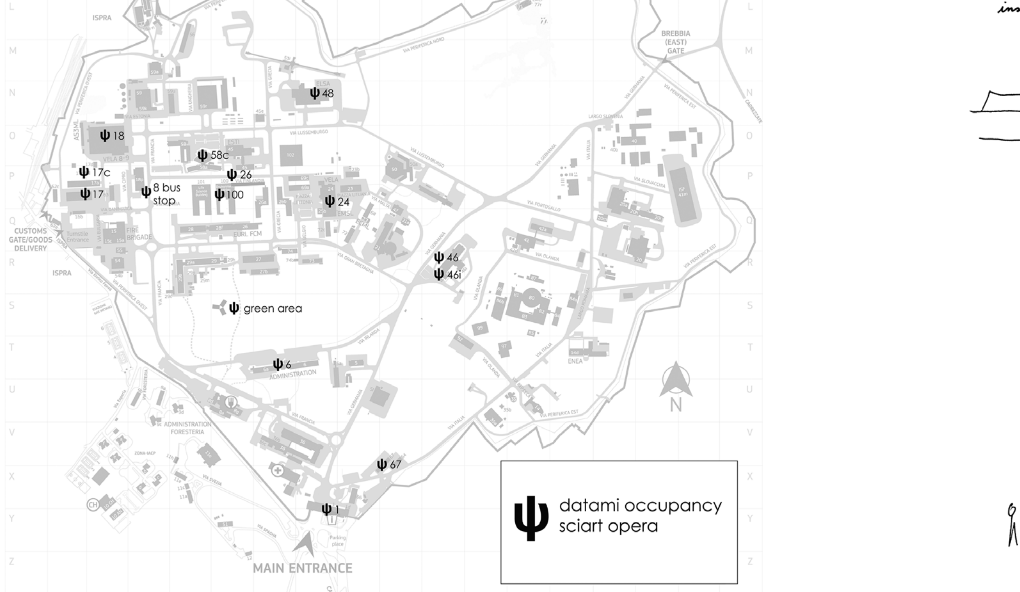
But when you go to an exhibition of contemporary art, you almost hope that

SCIENCE COULD BRING ART CLOSER TO PEOPLE

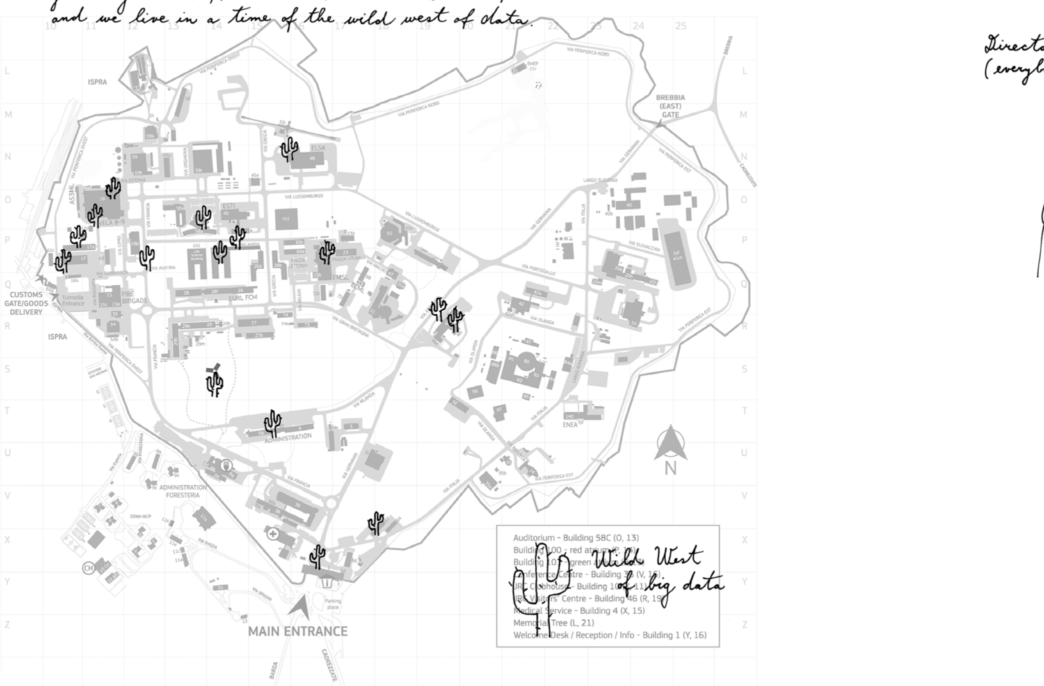
(One suggestion would be to do an anonymous peer review of artworks, as we know it from science.)

3
RESONANCES III FESTIVAL
(14. - 18. 10. 2019)

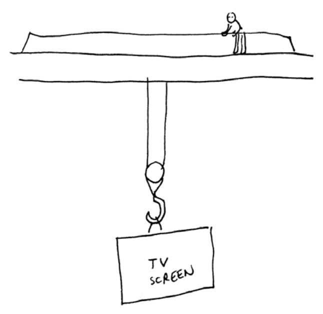
At first, I didn't get what the sign on the map of installations means.



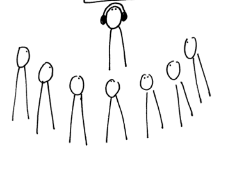
But now I think that it was actually a very good sign choice, because it looks like a cactus, and we live in a time of the wild west of data.



The JRC offers unique installation opportunities:



Director general treated as a king (everybody watches him watching)



The Making of Datami: a draft diary
Resonance III Datami, 2019
This diary was made during the Resonances III Festival
at the JRC site in Ispra [14.- 18. 10. 2019],
where it was presented in a kind of a stand-up comedy format
at the very end of the festival.