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10.0 Writing Visual Culture

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Editor

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Abstracts

10.2 **'FUNDAMENTAL: The Cultural Negotiation of Radically Remote Science'**

Historically, the cognitive and imaginative dislocation of lay publics from the extreme abstraction of fundamental science has been understood as an issue to be addressed via public outreach initiatives; within this paradigm, the science itself is understood as essentially 'complete' and the task of communicators (sometimes with the added cultural advocacy of art) is to make the science more publicly accessible. Recent shifts in critical theory within the realm of New Materialism (Haraway, Barad), as well as questions regarding how empirical data can be reconciled with lived experience (Dowker), break down this rigid dichotomy of nature and culture; within this new paradigm, all fields are relational and contingent - but how do we negotiate this landscape in the context of cross-disciplinary research? This question is approached by looking at the specificity of practice-based strategies within two research projects (one recently completed and the other currently in R&D) that bring critical art practice into the sphere of radically remote science, exploring how we might approach knowledge-making practices in cross-disciplinary spheres as 'social-material enactments that contribute to, and are part of, the phenomena we describe' (Barad 2007, 26).

[click here for the full paper]

10.3 **'The Value of ArtScience: improving the balance in collaboration practices between artists and scientists can impact knowledge production'**

In a time in which scientific knowledge is in danger of being discredited, we return to the responsibility of art and science. There is widespread optimism that collaborations between artists and scientists can develop solutions to complex problems, co-create new knowledge and contribute to discovery and understanding. However, art-science pairings are often based on similar subject areas alone, and without structured efforts to enable cooperation. For artists and scientists, the path towards meaning-making is not guided by the same principles. The artist is not bound to scientific goals or facts and there is no obligation to produce truth, which makes art-science collaborations unique within inter- and transdisciplinary research. For scientific institutions or organisations, such collaborations are often perceived as 'art in the service of science' where outcomes of art-science collaborations are primarily seen as a means to communicate difficult scientific concepts to the public. It is rare that art becomes an acknowledged, integral ingredient in the production of scientific knowledge. This is surprising given the special psychological relationship of humans with art: experiencing art can lead to new ways of understanding and meaning-making — crucial for solving the complex and 'wicked' problems we are facing in the world today. Combining insights from the ongoing academic debate and my personal experience as an astrophysicist — and artist — who has actively worked in art-science collaborations for the past 12 years, this paper argues for a deep familiarity of the history and methodology of the other discipline as well as confronting one's own prejudice and biases towards the other discipline.

[click here for the full paper]

10.4 'Porous Bodies, Toxic Kin: Mapping the Massena Critical Zone'

This essay introduces a collaborative art research project that applies trans-corporeality as a method for mapping some chemical relations that make up a Critical Zone contaminated by Polychlorinated Biphenyls (PCBs). Our creative methodology leverages the conceptual framework of new materialist feminist theorists as a means to understand environmental health and justice through an examination of the porosity between bodies and the systems in which they are enmeshed. It emerges from personal injuries and the desire for justice, using trans-corporeality, as defined by Stacy Alaimo in Bodily Natures, as the structuring principle for a new ethical and political aesthetic engagement. Given the irreversibility of the damage done by these 'forever chemicals', the guiding question of the project is, how can we imagine new ways of living in a world severely altered by chemical pollution?

[click here for the full paper]

10.5 'Touch, Telepathy, and Tango'

This paper uses the findings of two art-science research projects to reveal insights into how brains work and how we think about how brains work. It uses these insights to suggest ways that art can engage more critically with neuroscience. During the One Thousand Mindreaders art-science research project, one thousand people were taught a little-known skill developed by Victorian stage mindreaders. By holding someone's hand and feeling their subconscious muscle movements, participants could find objects hidden in a room and duplicate unseen drawings that person had made earlier. The research suggests that such physical experiences of the embodied nature of thought can challenge the dominant neurocentrism of neuroscience discourse. An art-science research study of a direct-to-consumer EEG Brainwear device is then used to explore the history of scientific attempts to capture images of thoughts from early thoughtography to current neurotechnology. This history reveals the dangerously seductive allure of brain imaging technologies and the thought images they produce. Critical Neuroscience is a recent interdisciplinary initiative that encourages social, historical, and philosophical studies of neuroscience and the implications of recent advances in the field. There has been a call for a 'Critical NeuroArt' that responds to the concerns of 'Critical Neuroscience'. This paper suggests that such a Critical NeuroArt can benefit from art practices that have a quintessentially performative and embodied nature. It argues for utilising previously institutionally excluded art practices with a rich and relevant history of engagement with neuroscience and philosophy of mind.

[click here for the full paper]

10.6 'The Final Frontier of Fashion: Interdisciplinary approaches to design for microgravity'

Interdisciplinary projects for the commercial space age are dominated by collaborations involving engineers and technologists, with a goal to advance digital or mechanical technology. In the emerging field of spacewear design, collaborations with technologists have inevitably led to a focus on wearable technology. There are missed opportunities to explore how designed objects, including clothes, behave in microgravity. This research recognises that not all engagement with space travel is, or should be, high-tech. The condition of weightlessness forces fashion designers to revisit many of the assumptions that have long been fundamental to fashion design, in particular those related to the weight and drape of fabric, and the prioritisation of the silhouette. In order to develop a new field of spacewear design, an understanding of the effects of weightlessness must be sought through collaboration with physics and those with first-hand experience of weightlessness. This article introduces the need for such collaboration, and argues that these collaborations must differ in nature from previous art-science collaborations.

[click here for the full paper]

10.1

What The World Needs Now is Artists Engaging with Science

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Alana Jelinek, University of Hertfordshire

Introduction

Since taking on the leadership of the TVAD (theorising visual art and design) research group at the University of Hertfordshire, I have directed efforts towards my own research interests. This is a standard if slightly egotistical practice and I acknowledge the change in favour of research into a) art as a knowledge-forming discipline and b) inter- and multi-disciplinarity from the perspective of art (and to a lesser extent, design) practice. The TVAD symposium of 2020/21 reflected this preoccupation. The title was 'What the World Needs Now is Artists Engaging with Science' and we invited papers from artists, scientists and art historians and curators. The full programme and Call for Papers can be found at the end of this volume of Writing Visual Culture. The years 2020 and 2021 were CoV-2-SARS (Covid 19) years, when the world stopped moving at its ordinary pace and international travel became impossible. As such our symposium was delayed and online. The following five articles are peer-reviewed contributions from five of the speakers.

The essays span the perspectives of practicing artists, scientists and historians of art and design, including artist Fiona Crisp, astrophysicist-artist Ulrike Kuchner, artists Lisa Taliano and Maria Patricia Tinajero, performance artist Stuart Nolan and theorist of design, Barbara Brownie. I would argue, together they typify the profoundly differing viewpoints of the disciplines. Despite the differences, they are united on the question of the value and largely untapped potential of art-science collaboration. Arguably, this response was solicited through the provocation of the symposium. But I find it noteworthy anyway. It is noteworthy that practitioners in the field of art-science find it fascinating and important yet also underdeveloped and problematic despite the fact that art-science collaboration is a practice with many decades of history. Reading the contributions here, we see that reasons for the failed promise of art-science collaboration seem largely systemic. Commissioners of art, curators and funders, those with the money to enable collaboration between art and science, tend to understand the importance and value of science but not necessarily the value of art in its own terms. Instead they tend to view art in the service of science communication, as if art is a *lingua franca*, readily understood by audiences.

From my vantage point as an artist and theorist of art, writing about art as a knowledge-forming discipline, I find it noteworthy but unsurprising that the artists in this volume write as artists do, with artistic knowledge, history and shared values implicit in their viewpoints; in short, the implicit bias and norms of an artist. Whereas the scientist writes with the implicit bias and norms of a scientist, despite working with artists and as an artist, and the theorist has the outsider view

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of a non-maker, despite her personal experience of design practice. These five essays exemplify disciplinarity; they evidence that we each carry with us into our later experiences and practice the methods, biases and norms of our education; that each discipline has differing notions of excellence and knowledge. Our world views are formed profoundly by our training as undergraduates. At university or art school, we learn what type of knowledge to value and which are legitimate methods for obtaining and creating knowledge, including the practices and skills to hone in the pursuit of our discipline. Sometimes this education is formal, sometimes it is less formal and implicit. One example is the scepticism towards objectivity shown by the artists, exemplifying mores common to an art education. This can be contrasted with the scientist and her understanding of truth as a specifically scientific goal.

Some of the contributors have engaged in doctoral research in the arts, and others are artist-researchers or researchers in other disciplines beyond the arts and humanities. In making these distinctions, I do not denigrate anyone. I do not imply any hierarchy. I simply observe the differences between. There are many ways that hierarchies are lived and instantiated. In universities based on liberal principles, we claim to understand entrenched bias and we claim to attempt to mitigate its pernicious effects. Most of the time, we don't — and we know it. For this reason I need to be explicit that I am an artist and an academic researcher who also supervises and assesses doctoral research in the arts and humanities. However, this doesn't mean I cannot also value the contribution to knowledge — and to art as a 'knowledge-forming discipline' (Jelinek 2013) — that those without this training make. Nevertheless, I would stress that the contribution and the research is different depending on experience and training. Artists who conduct research for their artwork understand the histories, values, methods and knowledge of art. Artist-researchers similarly understand these, but research conducted by artists within academia is bound and informed by scholarly conventions in the arts and humanities. Notions of rigour and the need for evidence as defined by academia bind, guide and inform. By contrast, artists conducting research outside academia may be more fluid, though fluid heuristics is also found within academia.

In this volume, artists Taliano and Tinajero describe their research into toxic PCBs in Massena, NY, USA as citizen-scientists who rely on science to prove the toxicity and concentration of PCBs in the local area, and as citizen-journalists investigating a history of leaks and dumping by industries local to Massena, searching for evidence. Taliano and Tinajero engage with information as artists, creating artworks and exhibitions that employ the languages, history and values of art practice to explore the implication of PCB toxicity, a systematic lack of corporate responsibility and a chronic lack of accountability. They use their art practice to communicate their knowledge and concerns

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with non-art audiences and also with other artists. Their peers are other artists in the participatory art-science tradition, including for example, Meghan Moe Beitiks, whom they cite. Taliano and Tinajero are artists making artwork in a specific tradition. The art process and product of their research can be judged as successful, if judging is what you do, in the participatory tradition. They may be judged in terms of aesthetics, as Claire Bishop (2006) urges, and/or in terms of efficacy as participatory politics, as Grant Kester (2004) and Gregory Sholette (2017) advocate.

I would argue that to appreciate their contribution, we must engage with it appropriately, understanding its positionality. This we must do for all our contributors, for all artists. It is the basic call in any inter- and multi-disciplinary work. We must engage the other as Other and avoid imposing our own self-defined values and mores onto the Other (see Critchley on Levinas). We must attempt openness to the contribution of the Other, navigating differences ethically and without imposing the Self, our assumptions, values and mores or our narcissism (Critchley 1999).

In this volume, Crisp argues that 'we need to pay more attention to how artists are asking questions. This point is of importance because it attends to the catalytic dynamic of artists' practice and the role it plays in creating new knowledge in highly specific ways through doing' (original emphasis). Crisp's contribution to this volume describes and analyses her experience as an artist working on art-science collaboration with physicists, particle physicists and cosmologists (those who pursue scientific study of the cosmos). These are sciences with mathematics as their language of enquiry, exploration, analysis and meaning. Arguably, the centrality of advanced mathematics is the reason for its inaccessibility. While arithmetic is grounded in the real and the everyday, algebra is the language of abstraction. The unknown and the possible are expressed by the language of algebra. Algebra holds the nuance and (im)possibility of multiple-state simultaneity. These expressions are often illusive in the spoken languages, making the translation of algebra into say, English, difficult and problematic. Crisp's project is to go beyond these languages. It is not about making scales palpable. Her aim is to take the abstraction, the 'radical remoteness' of these sciences, and create a sensorium for them so they can be experienced. She is clear that she does not use photography and the moving image to document, as others seem to require of these tools and of her as an artist. Instead Crisp uses these tools to ask 'if the photograph or film object can become a site of phenomenological encounter'. In questioning 'the limits and capabilities of photography', Crisp investigates 'how something is looked at by the camera, as much as what is looked at', making it an artistic investigation and not a project to communicate the science.

Crisp's contribution is followed here by Ulrike Kuchner's, an astrophysicist working with artists on

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art-science collaborations who also makes art.[1] She similarly argues that the promise of art-science collaborations is not being met, and draws on her own experience. One of the differences between Kuchner's approach and those with an arts and humanities background is her emphasis on application. Kuchner writes that 'expressing complexity that leads to application is perhaps the most challenging part of communicating science and without it 'research is unfinished"'. The emphasis for scientists is on application, whether or not an observation or thesis is applicable beyond academia. As purveyors of an often uncomplicated truth, scientists as a rule want to guide action towards (their) truth, a truth defined as empirical and universal. Kuchner writes:

> artists are free to mix fiction with facts. The artist is not bound to scientific goals or facts and there is no obligation to produce truth or to serve the dissemination of knowledge, which makes art-science collaborations unique within inter- and transdisciplinary research.

Many artists might agree with Kuchner about this. But I have argued at length about the role that truth plays in art, and always has played, despite the disavowal of truth since the intrusion of an overarching, simplistic and reductive postmodernism in the arts and humanities since the 1990s (Jelinek 2020). My argument is not to revert to a transcendent universalism, which is ineluctably Eurocentric and patriarchal, but to digest the lessons of poststructuralism whilst also retaining the value of truth.

Kuchner writes that 'communication of results is, of course, a vital part of academic research. It demonstrates knowledge, informs and convinces, and ideally motivates action' (original emphasis). Taliano and Tinajero might agree with the emphasis on action. They are similarly driven to action, specifically, the clean up of PCBs and an end to the production of such toxic substances. Kuchner writes, 'Art is arguably better equipped than fundamental science to [motivate action], because it more frequently joins thinking with doing, reflection with action'. I argue similarly in *This is Not Art: Activism and Other Not Art* (IB Tauris 2013) with philosopher Hannah Arendt in mind, stressing the importance of art as democratic action in the instantiation of difference in public. However, action is not the same as application. A scientist considers the application of their research, an artist action (and artists such as Crisp remind us that, for some artists, it is not a question of action, but perception, that art alters perception, that art produces knowledge without immediate application).

Stuart Nolan's contribution here is a description of part of his doctoral research and it does have *application*, to use Kuchner's term. He wants his research into mentalism to move general understanding away from outdated and simplistic ideas of the brain as presented by neuroscience.

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His is a critical art practice in the vein of the Frankfurt School, critiquing normative science with art to expose the ideological bias within neuroimaging. Marxist art theorist John Roberts insists all art-science collaboration should serve this purpose (Roberts 2016, 112). In exposing the ideological roots of neuroscience, Nolan's practice is an activist one. It is political and interventionist. The aim is real world change. Nolan wants to intervene into a pernicious future directed by big tech. His aim, similar to Taliano and Tinajero, is to bring to light knowledge and criticality that empowers the individual against - or within - dominant discourse and exploitative powers.

Nolan and Crisp both employ their art practice in dialogue with text-based philosophy: Crisp works with text-based engagements with phenomenology and Nolan with philosophy of mind. He writes:

> A 'kinaesthetic emulation of muscle reading practices brings the body to bear on mentalism's performance philosophy of mind and makes visible a neglected practice of the unseen, the speculative, and the imaginary in the historical and contemporary conception of energy and forces as aesthetic interventions'.

My own art practice is similarly placed within and against text-based philosophy. In my case it is mostly aesthetics. I use art practice, the methods, values and processes endemic to art practice, to comment on and contribute to the text-based aesthetic philosophy contributions of George Dickie and Arthur Danto. This is one of the many ways with which artists engage with, and think through, disciplines in addition to their 'home discipline' of art; how artists may conduct inter-, cross- and transdisciplinary research, both within and beyond art-science collaboration.

The final essay published here is by Barbara Brownie, quondam graphic designer and theorist of clothes design. Much of her recent research has been into 'spacewear' and the problem of a lingering 1960s 'retrofuturist' aesthetic in contemporary designs. Hers is a critical investigation into designing for microgravity and a call for greater collaboration between artists, designers, physicists and those with lived experience of microgravity. Similar to Nolan, Brownie wants to shake up a field. She wants to draw attention to various tropes and assumptions that linger from history and which problematically inform present design and knowledge habits. She writes:

> Despite the 15 years that have passed since Matsui's creation of the zero-gravity wedding dress, fashion designers have not yet revisited the creative possibilities of weightlessness, favouring instead a focus on wearable technology, steered by the spaceflight industry's prioritisation of collaboration between design and engineering or technology. As a result, there

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> are missed opportunities for the fashion industry to creatively engage with weightlessness, and for the spaceflight industry to develop flight suits that visibly engage with the effects of weightlessness in a way that may appeal to the next generation of space tourists.

Brownie and Nolan share a scepticism towards the contribution of technologists and engineers, calling instead for more involvement with artists and others who can think through non-nomological solutions (perspectives from beyond the laws of science). Notably, Brownie differentiates between science per se and the applied sciences, such as engineering. For her, engineers and technologists tend to the problematically normative, whereas scientists do not:

> In order to exploit the creative potential of microgravity, the field needs to move away from collaborations with engineers and technologies, towards collaborations with disciplines that have an understanding of weightlessness and its effects, that is, with the field of physics.

Exploring different starting points, different ways of seeing and being is a genuine strength of art practice. It is one of the true potentials of artists and designers engaging with science. If we leave the future to engineers and politicians we end up with increasingly narrow questions and solutions. Art allows us to think again and differently.

Acknowledgements

Each of the articles, including my introduction, has been peer-reviewed and subedited. I want to thank the numerous anonymous peer reviewers who generously gave their time, offering their expertise to the authors. I believe all our work is improved by this process and I acknowledge it can be quite painful.

Notes

[1] In response to my characterisation of Ulrike Kuchner as a scientist who makes art, she writes: ‘I find it important to clarify that I have an undergraduate and masters degree in arts (University of Applied Arts Vienna 2010) as well as in science, and a PhD (University of Vienna 2017). Therefore, I am professionally trained and qualified in both disciplines. I have also worked in the arts/creative sector independently and collaboratively — mainly in ArtScience (which is important in this context) — as well as in scientific research for more than 10 years. To position my contribution as coming from a purely disciplinary background of a scientist therefore falls short in my opinion.’

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10.2 *FUNDAMENTAL*: The Cultural Negotiation of Radically Remote Science

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Fiona Crisp, Northumbria University, Newcastle, UK

FUNDAMENTAL

In the summer of 2018, I was transitioning between two research projects: *Material Sight* (2016-18) [1] used critical art practice to examine the use of visualisation in fundamental science and explored how non-documentary photography and moving image might be used to embody a sense of material encounter at three world-leading research facilities for particle physics, astrophysics, and cosmology. The project resulted in several outcomes, including two exhibitions and a book[2], but, most importantly, the project brought together a constellation of artists, scientists, philosophers, curators, and publics. Keen to channel this momentum, I began work on a new project, *FUNDAMENTAL*, which picked up on key findings from *Material Sight*. These were the possibility of critical art practice developing a 'sensorium' for fundamental science, the experience of 'phenomenological dissonance' that such an endeavour might necessitate and a desire to research how we culturally negotiate 'radically remote' science.

Material Sight, funded by a Leverhulme Research Fellowship, allowed me to spend a two-year period working with three world-leading facilities for fundamental science, namely, the Laboratori Nazionali del Gran Sasso - a set of subterranean laboratories for particle physics and astrophysics sited underneath the Gran Sasso Mountain Range in Central Italy; Boulby Underground Laboratory, located in the UK's deepest working mine, stretching out many kilometres under the bed of the North Sea; and the combined facilities at Durham University that include the Centre for Advanced Instrumentation and the Precision Optics Laboratory as well as the Institute of Computational Cosmology that produce, amongst other research, data visualisations of the origin and evolution of the universe, constructed using their super computer, COSMA.

It is extremely difficult to imaginatively or cognitively connect with the spatial and temporal scales of fundamental science that range from the subatomic to the multiverse. When we attempt to approach such ideas of paralysing abstraction through the perceptual range of our sensing bodies, a form of perceptual vertigo can be provoked. The experimental fields of physics and cosmology employ vast technical apparatus, often sited in physically extreme, subterranean environments; yet their object of study can only be witnessed through traces, experienced vicariously via remote sensing or by data constructions. The practice-based research undertaken for *Material Sight* has allowed us to understand the dissonance between the experience of material presence on the one hand and a sense of radical remoteness on the other, a 'phenomenological dissonance' (Crisp 2020). The project was premised on the question of how fundamental physics might be brought

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back into what the philosopher Edmund Husserl (1859-1938) called the 'Life World'; or, as the contemporary astronomer Roger Malina put it: 'How do we make physics intimate?' (Malina in Crisp and Triscott 2018). Working in partnership with the organisation Arts Catalyst, [3] *Material Sight* approached the question by developing experimental workshops and performance weekends, as well as through network building, symposia and publishing. At its core, the research was driven by the paradoxical desire to create a 'sensorium' for fundamental physics. We asked if photography, moving image and sound could *embody* the spaces of experimental science and also if these practices could present these spaces back to scientists and non-scientists alike, not as illustrations of the technical sublime (which we often see with image-making in relation to technology) but as sites of phenomenological encounter (Crisp 2020).

By the autumn of 2018, the new project, *FUNDAMENTAL*, was beginning to find a shape with areas of research activity mapped against partners and organisations - some existing/confirmed, others new/still to confirm - but at this juncture, when the project was in a state of open, necessarily unstable, dynamic potential, I was obliged to call a halt to all activity when I was diagnosed with cancer. After over a year of treatment and recovery, I was (thankfully) back in the studio, slowly starting to corral the ideas and working relationships that had inevitably shifted during/because of this hiatus. Then everything came to a halt for a second time: It was now spring 2020 and the whole world was brought to a standstill by Covid-19. I mention these events – one, life-altering on an individual level, the other a global pandemic that has seeped into every conceivable aspect of our collective lives – because they both matter for the research. As Karen Barad reminds us, 'practices of knowing and being are not isolable; they are mutually implicated' (2007, 185). Through this framing I acknowledge that, although both events have had – and continue to have – severely disruptive effects, it is the affective impacts of a messy, heterogeneous, and emergent social world (Braidotti, 2011, 137) that are of ultimate significance for the research itself. Of course, one could argue that this is no more than the recognition of situated knowledge, whereby the experience of serious illness combined with the shifting sands of current global events has re-calibrated the relationship I have with the methodologies and subject of my research subject; but, as an artist and academic who has been working in cross-disciplinary spheres for many years, my thinking is in flux as at no other point in my career. In this context, I find myself asking where we, as artists, should situate our work so that the conditions and structure of our 'endeavour' might map over the critical, conceptual, and socio-political dimensions of the questions we are asking, and wondering whether it is here that we need Barad's 'ethico-onto-epistem-ology' as an 'intertwining of ethics, knowing and being' (2007, 185).

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FUNDAMENTAL: The Cultural Negotiation of Radically Remote Science

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The excellent symposium that has shaped this journal publication proposed: 'What the world needs now is artists engaging with science'. There is much to unpick in this provocation – not least the historical issue of nomenclature that has produced the false binary of 'Art' on the one hand and 'Science' on the other. Added to this is the disciplinary a-symmetry, observed by Barry and Born (2010), whereby the 'Science' in Art and Science has always been perceived as essentially 'complete' and, by extension, that art's engagement with science is primarily interpretive (or illustrative) with the ultimate, instrumentalised goal of improving public understanding. Sleigh and Craske (2017) have gone on to explore the historical roots of these binaries in the UK, plotting the first funded wave of Art and Science (A&S) via schemes such as the Wellcome Trust's Sciart (sic) programme (1996-2006), concluding that within this era, 'The lightweight epistemological justifications that were given, concerning the complementarity of art and science, were not strong enough to surmount their institutionalized asymmetry' (2017, 317). Whilst there have undoubtedly been advancements in the subsequent decade and a half, it must nevertheless be acknowledged that the legacy of these foundational asymmetries has been hard-wired into the policies and politics of almost all inter, cross and trans-disciplinary work between art and science and therefore define its funding structures. Consequently, we are too often faced with transactional relationships where artists' access to science is predicated on the delivery of public outreach and impact agendas.[4]

So, while the world does indeed need artists engaging with science (and vice-versa), we also need everyone – scientists, artists and publics – engaging with the multiple cultures of science and technology in the context of our current socio-political realities. But how do we inculcate this engagement and make it proactive? To return to my question about artists' endeavour, I would suggest that we need to pay more attention to how artists are asking questions. This point is of importance because it attends to the catalytic dynamic of artists' practice and the role it plays in creating new knowledge in highly specific ways through doing. Creating advocacy for the specificity of practice – especially in experimental and performative contexts – is the one of founding principles of The Cultural Negotiation of Science (CNoS) [5], a research group led by myself and fellow artist Christine Borland. Founded in 2013 when we produced the exhibition and symposium, *Extraordinary Renditions*, at BALTIC Centre for Contemporary Art, [6] CNoS includes artists, research staff and postgraduate researchers who critically engage with expert cultures across a broad spectrum of fundamental, bio-medical and climate science, as well as with the fields of genetics, geology, botany and museology. An important aspect of CNoS's critical engagement is advocacy for shifts within the cultures of science - to support, for example, different approaches to subjectivity, diversity, and gender; for the recognition of 'doing science' as a human activity and cultural endeavour; and to acknowledge the entanglement of science with the socio-

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political sphere. Indeed, in this respect, it is beholden on us all to acknowledge, what the historian of science, John Tresch, describes as 'the disorientingly plural, technologically modified, politically and environmentally precarious worlds we now inhabit' (Tresch 2014, 167). [7] Against this terrifyingly unanchored backdrop, I have found some grounding in Maria Puig de la Bellacasa's linking of knowledge politics with feminist politics when she asserts that 'knowledge-making processes are inseparably world making and materially consequential' (2009; 299); this seems to me to be the crux of interdisciplinary knowledge-making – *not* the transactional exchange of services we too often encounter.

I also concur with Puig de la Bellacasa when she takes Marx's famous phrase 'philosophers have only interpreted the world, the point is to change it', and updates it to her own version: 'theory has only observed the world; the point is to touch it' (2009, 299). The idea of 'touch' sits at the centre of my practice. My compulsion has been to work with fundamental scientists – particle physicists, astrophysicists, and cosmologists – a choice that could be seen less as Donna Haraway's idea of 'staying with the trouble' (2016) and more along the lines of seeking out the trouble as I have been increasingly drawn to the extreme abstraction of these fields of knowledge-making and their radical intangibility. The 'tools' through which I pursue this extreme remoteness, however, are the materially prosaic means of the contemporary artist; in my case, photography, moving image, sound, sculpture and installation. To be clear though, this does not mean that the research is premised on visual aesthetics - my use of photography is not primarily as a visual medium, but rather I am asking if the photograph or film object can become a site of phenomenological encounter. Significantly, it was the questioning of the limits and capabilities of photography that drove the project, *Material Sight*. In other words, it was the idea of radical intangibility that had emerged out of a long history within my own practice working with the photographic and film object, now explored in the context of fundamental science, that was the driver of the project.

Developing my science partners' understanding of (and engagement with) the specific positioning of the research was a large part of the challenge, interest, and impact of *Material Sight*. The research fellowship took place over a two-year period, but the working relationships were fostered, and methodologies trialled, over several years prior to the project commencing. This lead-in time enabled me to counter some of the preconceived views held by my science partners about the methods and motivations of an artist working within laboratory environments and wider sites of fundamental science: views that I understood as revolving around three, somewhat contradictory, assumptions. First, was that working with photography and moving image would inevitably produce documentary images; second, that the primary purpose of the project was to communicate science

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to public audiences; and third that my approach as an artist would be centred on visual aesthetics. I refer to my work as non-documentary; this is because, even though the photographs and films are, in literal terms, a document of a specific site, they are not driven by documentary intent. By this I mean that there is no narrative drive, no conveyance of meaning beyond the image's own, internal presence – in this respect it is *how* something is looked at by the camera, as much as *what* is looked at. These are of course complex ideas to convey when working in the field. Negotiating access to a site (particularly where access is difficult, dangerous, or limited to specific personnel) and then arriving with film, photography, and sound equipment, develops an expectation from the host organisation that some form of document will be made via either the narration of histories or the communication of information. In theoretical terms (thinking about histories of photography and the conflicted position of my practice within it) I have come to think about this expectation as a form of 'documentary burden', but when working in the field, particularly in cross-disciplinary contexts, I have come to recognise that communicating the intentionality of the research in the early stages of a project is key. In this way, I have been able to establish that the practice and research is an engagement with the combined physical, philosophical, and conceptual concerns of fundamental science and this specific engagement will therefore influence how I may use my own technical equipment (still/moving image and sound). Crucially, the specificity of this engagement will influence how material becomes manifest for a public audience through exhibition or publication. At the same time, I am also able to address any expectations that the research will straightforwardly fulfil public outreach agendas.

Interestingly, the view that an artist's involvement in cross disciplinary research is, by default, centred on visual aesthetics, is still remarkably common. In the same way that the a-symmetries instrumentalising art and influencing funding structures in cross-disciplinary research persist, the perceived differentials of 'purpose' assigned to Art and Science throughout much of the twentieth century also remain hard to shift. The British aesthetician, Harold Osborne exemplified this position when, in 1981, he wrote 'scientists are motivated by the human urge to seek new knowledge for its own sake, fine artists by the impulse to provide and enjoy visual material for the expansion of aesthetic experience' (1981, 290). [8] Despite the fact that this view would have been considered anachronistic by most artists, educationalists, and critical theorists when it was written forty years ago, Osborne's statement reflects the paradigm that many scientists and funding/commissioning bodies tend to adhere to today. If asked, many fundamental scientists will speak about ideas of 'beauty', 'order' or 'patterns in nature' forming the key interface of their own discipline with the field of art. This is unsurprising since, in common with the population at large, most scientists have not been exposed to the idea of art practice as an expanded, critical, socio-politically engaged

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discipline – especially one where ideas of visual primacy (Jay) or visual objectivity (Daston and Galison) are acknowledged as contested concepts.

There are, of course, many scientists who are fully conversant with critical art practices and, as such, already comfortable with the speculation and (productive) uncertainty that working with artists can bring. [9] These scientists are often catalytic in cross-disciplinary research because they can produce confidence in a wider group of peers to move out beyond the comfort zone of one's discipline. I have found that encouraging a shift away from discipline-specific norms can be a vital aspect of new knowledge production and, to this end, I have used a creative strategy of constructively 'wrong-footing' fellow researchers. Akin to the idea of 'purposeful dislocation' (Ferguson and Gupta) in anthropology, wrong-footing can be brought about by small shifts in behaviour or action within the cultures of specific disciplines. An example of wrong-footing in action would be the request given to the physicists contributing to the publication *The Live Creature and Ethereal Things: Physics in Culture* to write in the first person. With this invitation, editors Nicola Triscott (then Arts Catalyst Director) and myself understood that we were encouraging a transgressive act from researchers bound by codes of objective knowledge and collective intelligence.

The research methodologies of *FUNDAMENTAL* will build on the creative, practice-based strategies developed in Material Sight whilst also looking at how other, historical models might inform contemporary thinking. A useful attitudinal approach, for example, could come from Deleuze and Guattari's (1988, 369-370) advocacy of a 'minor science' that runs alongside mainstream, major or 'royal' scientific endeavours (1988, 367):

> Whereas the latter developed formal disciplines in the natural and social sciences to underpin authoritative statements about the world by monarchy, State or societal establishment, minor science is practically oriented: providing local knowledge to achieve specific tasks while acknowledging a world that is dynamic and heterogeneous rather than stable and consistent. (Fox and Alldred 2019, 10)

What differentiates the two scientific approaches is their sense of attitude towards their objects of study; whereas major or royal science would be driven by empirical approaches toward producing data evidence, a 'minor science' perspective might come from immersion in the flow of events as they unfold:

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> Rather than observing and documenting a river and its contents from a fixed point on the bank, Deleuze and Guattari (1988, 372) suggested, minor science takes to a boat and becomes part of the flow it wants to fully understand. (ibid)

Another area that *FUNDAMENTAL* will look to develop is new approaches to the idea of the artists' residency, asking what it is to work across and in-between cultures of practice and what might be done to 'crack-open' a form of interstitial space, building on historical models, such as the Artists Placement Group (APG). Founded in the UK in the 1960s, the APG described themselves as having developed the first 'industrial artist-fellowship' where the artist could be an 'engineer of conceptual material' (Rycroft 2019, 295). With an emphasis on process rather than product, APG organised for artists to be embedded in government and non-government organisations, including Esso, ICI, British Rail, the Department of Health and British Steel. Whilst the idea for the APG as an organisation can probably be attributed to Barbara Stevini, (ibid, 293) it was her partner, John Latham, that provided the framing of the artist as an 'Incidental Person'. The 'IP', as they were referred to, could affect thinking within the organisation, operating far outside the usual remit of an artist's placement, consulting on issues such as 'environmental protection, urban design and urban renewal, environmental engineering, communications technologies, production systems and human resources' (ibid, 296). To a large extent, the APG's radicality resided in the fact that it was led by art practice; in this respect, the fact that the group persuaded large-scale industrial and administrative organisations to engage with a remit premised on the idiosyncratic 'cosmic speculations' of John Latham, can be seen as an extraordinary achievement.

The APG does not provide a conventional model for cross-disciplinary practice but this, I would argue, is its value in the context of the a-symmetries and false binaries that have been described. In this context, it is an historical precedent that, together with the critical lens of New Materialism, can be used to constructively de-stabilise the art-science binary as well as exploring questions of how empirical data can be reconciled with lived experience. Through this approach, *FUNDAMENTAL* seeks to challenge existing, instrumentalised models of collaborative practice between the cultures of arts and science and instead approach knowledge-making practices as, 'social-material enactments that contribute to, and are part of, the phenomena we describe' (Barad 2007, 26). In this respect, artist, scientist, and publics are placed inside of, and indivisible from, the knowledge-making process itself in what is a fundamental re-positioning with, potentially, profound implications.

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Notes

[1] www.materialsight.wordpress.com

[2] Crisp and Triscott. 2018

[3] Arts Catalyst https://www.artscatalyst.org/

[4] Sleigh and Craske go on to outline changes made in the 'second decade' of A&S (2006-16) where, as well as cultural-political factors coming into play, there has been the adoption of the idea of 'creativity' as, 'a sort of epistemology-lite that is used ubiquitously to describe the working method of both science and art'. (2017, 317)

[5] The Cultural Negotiation of Science https://www.cnos.ac.uk/

[6] Extraordinary Renditions http://fionacrisp.com/Website%20update EXTRAORDINARYRENDITIONS.html

[7] I am grateful to Adrien de Sutter for introducing me to the writing of John Tresch.

[8] In this statement Osborne differentiates what he calls 'basic' or 'pure' science from applied science and fine art rather than applied art.

[9] Interestingly, I have found that scientists in this category often have some relationship – partner, sibling, child, or parent – with an artist or creative.

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10.3 The Value of ArtScience

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Ulrike Kuchner, University of Nottingham, UK

The Value of ArtScience: improving the balance in collaboration practices between artists and scientists can impact knowledge production

How we teach is not how we learn

Interdisciplinarity is an ambitious endeavour. Despite the challenges any engagement between more than one discipline or collaboration of highly specialised individuals face, there is widespread optimism about inter- and transdisciplinary work in general and between art and science in particular. The aim of such collaboration is to develop solutions to complex problems, co-create new knowledge or to collectively transform multi-faceted challenges into new ways of understanding and meaning-making.

In many ways this approach contradicts how we learn in an academic setting: we teach by communicating specialised information in specific ways and environments, encouraging one aspect of (creative) thinking at a time. For example, a calculus program is designed to foster skills in mathematical reasoning and analytical thinking, while a specific design or art course trains skills related to the imagination and visualisation. Philosopher and science historian Jörn Heinrich encourages interdisciplinary teaching with an illustration of this dichotomy and its potential limitations:

> Today's science system is still locked in categories introduced in the 19th century: the natural sciences offer nomological explanations while the humanities use hermeneutics. Although hermeneutic methods are used in natural sciences and explanations are based on laws in humanities, I argue that this thinking in strict categories can hamper progress. (Heinrich 2014)

Despite the apparent standstill in teaching approaches, researchers naturally use methods that are typically associated with other disciplines in order to advance their understanding. This reflection allows us to think that we are all capable to work, learn and teach interdisciplinarily.

Collaboration, creativity, imagination and innovation skills are the declared outcomes of twenty first century learning (for example, Nakano 2018) and prominently feature in considerations of employability in today's highly competitive and congested global market (Helyer 2015). However, philosopher and art historian, James Elkins argues that a comprehensive approach to creativity is hard to teach; nor can 'wonder' and 'intuition' be taught, which, Elkins writes, may all be 'administrative categories to help along language' (Elkins 2017). How then, should we learn these

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sought-after skills that promise new insights to problems and so often feature prominently in job advertisements and organisational decision-making processes?

Pedagogies that combine associated approaches from multiple disciplines could help. This way of teaching contributes to 'counter balance the isolation of specialisation … develop integrative and collaborative skills in students and respon[ses] to societal problems' (Klein 2010). Interdisciplinary courses and programs with active learning approaches may produce an interdisciplinary understanding of the problem which can be tested. In addition, according to Professor of Higher Eduction, Lisa Lattuca, interdisciplinary teaching 'better prepares students for work and citizenship by developing higher-order cognitive skills' (Lattuca 2004). Admittedly, integrating disciplinary insights is an 'extremely complex mental process', as Professor of Teaching, Leadership and Curriculum Studies, Gordon Vars, points out (Vars 2002).

The increasing awareness of the benefits of interdisciplinary and transdisciplinary thinking may contribute to a growing interest in the relationship between the arts and sciences in education and beyond. Art and science — in the form of collaborations or undertaken by an individual — are an indispensable feature of our cultural landscape with increasing awareness in creative academic disciplines [1]. Today, art and science modules are part of many art school curricula and there is an increasing number of SciArt labs and transdisciplinary studios such as Studio Olafur Eliasson in Berlin, Hangar in Barcelona and Martin Boyce Studio in Glasgow.

In this paper, I give a conceptual analysis of collaborations between professional scientists and artists, explore reasons for the common disparity between anticipated involvement and outcome and discuss the underused potential of such art-science collaborations. (Note that interdisciplinarity does not have to be collaborative and can of course be undertaken by an individual. However, this is not the focus of the present paper.) My observations and analysis are based on personal experience as an artist and scientist actively working in ArtScience both individually and as part of collaborations, including insights based on formal and informal discussions with artists, scientists, teachers, curators, and researchers that have all been part of art-science collaborations. Note that larger interview-based research (for example, Schnugg 2020) and/or quantitative research (Birsel et al in prep) into ArtScience collaborations is also necessary, though not the method used to write this paper. In this paper, I will use a few of varieties of terms that relate to collaborations between artists and scientists including, SciArt, ArtScience, art-science (Rock and Adler 2019). Similarly, I acknowledge that 'the arts' and 'the sciences' is a gross simplification and abstraction of a compound of disciplines and sub-disciplines. Equally, the binary

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statements and 'labels' are used as a reduction to assist readability and comparison. In this paper I will examine the perceived disparities between anticipated involvement and outcome of art and science collaborations, before attempting to understand reasons for this. In this context it is useful to investigate the different approaches of working together. Finally, I explore the underused potential of art-science collaborations for knowledge-creation and decision-making.

Imbalances of expectations

> Interdisciplinarity plays a paradoxical role: it is the result of efforts to build bridges, but at the same time it is evidence of the boundaries between different discourses. (Holtorf 2014)

The particularities of context, material and knowledge and differences in modes of expression, sharing and exchange of information, are evident in the arts and the sciences. Collaborations between artists and scientists are a constant cooperative relationship, often with the goal of fostering understanding, developing ideas and making art (amongst other outcomes). However, for the sciences, the relationship between arts and sciences has often been perceived as 'art in the service of science' (Roughley 2018); a means to visually enhance, interpret or communicate complex scientific ideas with the general public. The communication of results is, of course, a vital part of academic research. It demonstrates knowledge, informs and convinces, and ideally motivates action. Expressing complexity that leads to application is perhaps the most challenging part of communicating science and without it 'research is unfinished' (Chris Lintott, during a talk given to IAU Early Career Researchers, December 2020). Scientists and technologists are rarely well equipped to connect the 'unfamiliar scientific image' (the world as described by science) to the 'familiar manifest image' (the world as it appears to us), a dichotomy first introduced by the philosopher Wilfrid Sellars (Sellers 1962, van Fraassen 1999). Art is arguably better equipped than fundamental science to do this, because it more frequently joins thinking with doing, reflection with action.

The argument for using art as a means of communicating science is strengthened by tangible processes that happen when audiences interact with art. Individuals that experience art in an art situation have been shown to 'try harder' at understanding the meaning, or to persist even if the meaning is first hidden: the art situation 'allow[s] us to believe that [a work] has a subjective meaning even when we cannot grasp what it is', psychoanalyst Michael Parsons argues (Parsons 1987). Although these claims do not come without contestation (Pariser 1988), creative ways championed by the arts are often welcome contributions to communicating results to both the unpredictable and selective audience of the general public, and also to the captive and (seemingly) well-defined audience of a knowledgeable

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academic professionals. The way in which art is delivered creates thinking space, which is necessary to comprehend that which is communicated.

Art conveys insights into how we understand the world around us and can thus crack open cemented opinions and challenge the given. According to philosopher, John Bender, art can lead to changes in the way we think about and comprehend knowledge (Bender 1993). The caveat is that artists are free to mix fiction with facts. The artist is not bound to scientific goals or facts and there is no obligation to produce truth or to serve the dissemination of knowledge, which makes art-science collaborations unique within inter- and transdisciplinary research (see below for definitions).

Understanding gained through art is not based on a differentiation between fact and fiction. Psychologist Matthew Pelowski writes on processes in art perception:

> Driving this relation of humans with art is a special psychological experience. Art can engender myriad emotions. It can evoke personal associations, cause diverse perceptions, evaluations, and physiological response. Art can also lead to new ideas. It can change conceptions and resonate with viewer mood or personality. (Pelowski 2017)

Art can therefore take and communicate positions on emotional levels that are fundamentally not available to peer-reviewed science communication practices. Art that engages with scientific concepts and findings can therefore increase the impact and reach of scientific research. This is one important reason why art-science collaborations so frequently feature as projects related to public engagement or scientific outreach (Sian 2019). Note however that even beyond the ‘fact vs fiction’ uncertainty, a profound (scientific) insight from viewing and experiencing art is not a given nor is it unambiguous: a residual mystery or ambiguity might be left open and accepted. In addition, artworks can often be experienced repeatedly, potentially leading to different solutions or understandings at different times (Pelowski 2017). How then can we legitimise the temporary understanding or new knowledge that a beholder experiences through art? Confirming or quantifying an empathically learned aspect of science, for example, through proof or approximation is difficult. It is important to remember and acknowledge that the goal of the artwork or artist is solely defined by the artist and therefore such legitimisations likely do not feature in the work of the artist.

In art-science collaborations, the different cultures — abbreviated here as the aesthetic and the analytic — collide. While art can be an important ingredient for understanding scientific phenomenon, concept or theory, art-science pairings are rarely truly collaborative (Roughley, 2018): it is uncommon that artists

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are invited to co-author scientific papers, art classes are not part of the general academic curricula of science subjects, nor does art feature in considerations for grant applications beyond public engagement. In practice, artists collaborating with scientists and technologists are often perceived as external observers that learn, draw this newly learnt knowledge from its environment, and add an artistic, social, or subjective perspective to a known problem. Despite humanity's strong need to understand 'the big picture', and the role of the arts place in achieving this, it is rare that art becomes an acknowledged, integral ingredient in producing scientific knowledge. Nor is art integrated in decision-making process of complex societal challenges. It seems that while sciences are open to 'borrowing' methods from other disciplines for the communication and advertisement of results, the paradigms of creating knowledge in sciences are somehow 'sacred' (Heinrich 2014).

Scientists rarely capitalise on the expertise of artists during these art-science collaborations. Interdisciplinary researcher Svenja Kratz and practitioner Anita Gowers summarise this conundrum as follows:

> Despite the relative success of art-science collaborations in creative and academic arenas, it remains a field that is poorly understood by outsiders resulting in the wide-spread perception that the primary purpose of art is science communication. Without consideration, the flows between disciplines can also be rather one-sided with artists relying on the expertise of scientists to develop their work with little creative input and limited benefit to their own scientific research. (Kratz and Gowers 2017)

I find that this problem is not only perceived by outsiders. Rather, participants of collaborations, including students and researchers at universities and organisations, finish collaborative projects that are 'branded' art-science feeling misunderstood or dissatisfied. The scientific academic institution often capitalises on the resulting art pieces for the (sole) purpose of science communication and public engagement, increasing the institutions' profile in these areas rather than benefiting the research and collaboration directly. This may be a result of the increasing emphasis of public engagement in funding schemes and grants, such as UK's Science and Technology Facilities Council or USA's National Science Foundation. In addition, scientists that are not included in the artistic process often feel their research was misunderstood or 'lost in translation'. It is easy to speculate that the imbalance or the superficiality of treatment is founded on misunderstandings or (innocent) ignorance of the other disciplines' intentions and ways of working. After all, C. P. Snow famously concluded that the divide between the two cultures came about because neither understood the other's methodologies or goals (Snow 1959).

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As with successful collaborative work within a single discipline, the group of individuals trained in different fields relies on personal communication, a willingness to learn from all participants, and the ability to openly question one's own notions. However, the added difficulty in collaborations between far-removed disciplines is to gain a level of familiarity, to become a 'well-informed amateur' of another discipline in a relatively short amount of time, including its history and methodologies. Importantly, this process of familiarisation includes confronting ones own prejudice and biases towards the other discipline.

Further, reasons for the imbalance can be found not only in misunderstandings and an asymmetry in the expectations of art-science collaborations, but also in the different measures of effectiveness and impact. The reluctance to implement artistic methods as methodology in scientific research or to integrate them in the decision making process of challenge-based research could be due to tensions between the different disciplinary approaches. This imbalance is not one-sided: artists do not think of scientific communication as 'added value' for their artwork. This is not surprising since methodologies and approaches of the different communities often seem incompatible, which makes calibrating and integrating standards and approaches fraught (Klein 2008). All of this presents a challenge for adopting operational aspects of communities outside of one's own subject area. This is certainly more relevant for quantitative scientific research where methods must be reproducible, even reversible by peers — generally manifested as the result of a series of tests and/or experiments that become part of the analysis. To make this a requirement of an artwork is likely problematic for many creative endeavours. Therefore, an art-science collaboration, just as in any other interdisciplinary cooperation, needs to address questions related to the creation of theories and models in the different disciplines, how terms can be translated with as little loss as possible, and whether the participants are talking about the same or similar subjects (Jungert 2013).

Art historian, James Elkins, vividly describes art-science interactions as a kind of 'drunken conversation', that is they don't speak very clearly (Elkins 2017). Personally, I have found that a 'mediator', 'advisor' or 'translator' adequately familiar with and comfortable in both disciplines can have a positive impact by facilitating an ongoing exchange of information. This might include clarifying the type of cooperation that the individuals agree on (see below). While the methods of cooperation might evolve over time, having a mediator that summarises and interprets findings or practices helps all parties understand the common subject or problem, individuals' motivations and ways of working. Mediators assist understanding during this 'drunken conversation'. It is important to underline that it does not have to be the aim of art-science projects to produce new science — in fact, this is rarely the goal — but I found that a shared ambition strengthens the collaboration. The recognition that art can

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push aspects of scientific research forward in the same way that science can push art, reinforces the sense of involvement on a level playing field.

Ways of working together

To understand the disparity between anticipated involvement and the outcome of artists and scientists working together, and to increase incidences of successful (meaning satisfactory) collaborations, it is useful first to recognise and clarify the different ways that disciplines collaborate. As philosopher and historian of science Michael Jungert wrote, rarely has there been a larger gap between the frequent and wide usage and its theoretical reflection as for the term 'interdisciplinarity'. While it is widely hailed as an essential skill in any scientific and political context, the paucity of research on the topic is surprising (Jungert 2013). One reason could be the uncertainty of what interdisciplinary cooperation actually entails; perhaps it is transdisciplinarity or multidisciplinarity? The confusing use of terminologies is not new. In 1979, philosopher Joseph Kockelmans described the un-uniformity of these used terms (Kockelmans 1979). Since then, inter- and transdisciplinary research is more frequently included in relevant investigations such as in social ecologies studies, that investigate what enables the interaction, as well as philosophy of science, which traditionally searches empirically for differences and overlap of sciences, their practices and discourse (e.g., Maasen 2007). 'The multidisciplinary–interdisciplinary–transdisciplinary research environment spans a wide range of contexts', as Julie Thomson Klein, Professor of Interdisciplinary Studies, summarises (Klein 2008). However, so far, quantitative evaluations of interdisciplinary and transdisciplinary research has not included art-science collaborations specifically (to the best of my knowledge).

Laying out the general groundwork for the terminology and shining a light on the multiple connotations of the words and common usage may improve understanding about why research into transdisciplinarity rarely considers art-science collaborations. With an eye to the questions, 'What is the best that art-science collaborations can offer?' and 'What can be achieved by artists working with scientists that cannot be achieved by artists alone, or scientists alone?' [2], I will briefly reflect on ways that disciplines can work together and include some common understandings of the terminologies. Michael Jungert's (Jungert 2013) classifications are central to this summary.

The concept of multidisciplinary has been in use since the 1950s (Luszki 1958) and implies that the same or a similar subject areas coexist without (structured) efforts of cooperation or interdisciplinary synthesis of the individual scientific results. While the same topic is pursued and awareness of alternative approaches is acknowledged, each discipline answers their own questions independently using their own methodologies or decides within disciplinary boundaries without any attempt at

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integration or relation to one another, or to inquire about the mutual significance of disciplinary findings (Balsiger 2005). However, a common 'symbiosis' might be achieved after the project is completed (Mueller 2014). I find that art and science pairings often work in this way, especially when individuals were 'matched' based on their interests (such as subject area), and when time is short, or when collaboration is not actively facilitated.

Closely related, and often used synonymously, is the concept of pluridisciplinarity. However, according to Professor of Philosophy, Philipp Balsiger, pluridisciplinarity is the first stage of actual collaboration between different disciplines (Balsiger 2005). Jungert says that this type of cooperation does not involve any special coordination efforts and mostly takes place between 'related' subjects on the same 'hierarchical level' (Jungert 2013).[3] For others, pluridiciplinarity could be interpreted as a cooperation between familiar or related disciplines (Mueller 2014), without effecting their disciplinary identity. Pluridisciplinarity would rarely include the work of art-science.

Crossdiciplinarity takes this concept one step further and includes the idea of a common ground and conceptual framework which leads to 'genuine communication' between the participating parties (Kockelmans 1979). Thus, methods or research programs from another discipline — including disciplines far removed — are adopted for one's own subject (Jungert 2013). Approaches and findings of other disciplines are used to solve over-arching problems, however, the goals of each discipline remain within their existing boundaries. The term, crossdiscipline, blends with the everyday use of 'interdisciplinary' and is a common form of art-science collaborations. SciArt labs and long-lasting ArtScience projects and networks facilitate such collaborations.

By contrast, interdisciplinarians attempt to develop new research fields that eventually will lead to new disciplines (Mueller 2014). This approach is aimed at finding comprehensive solutions which 'cannot be addressed through a single discipline' (Harvard Project Zero 2016). Problem-oriented collaborations may be time-limited (Mainzer 1993), that is, connected to a specific project with finite duration, involving the application of theories, models or methods of one in another (Jungert 2013). It may 'range from simple communication of ideas to the mutual integration of organising concepts, methodology, procedures, epistemology, terminology, data, and organization of research and education in a fairly large field' (Apostel 1972).

Today, interdisciplinary work stands as an all-encompassing term for the entire range of cooperation models (Balsiger 2005) between different disciplines. Psychologist Heinz Heckhausen summarises the that the talk of interdisciplinary research usually means nothing more than some experts of different

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disciplines working together on a problem that is so general, everyday or alien that no representative of subjects involved has yet narrowed down and defined the problem under the aspects of their own subject matter (Heckhausen 1987). As such, ArtScience collaborations are interdisciplinary in nature. I find that artists (more often than scientists) approach the collaboration with an intriguing problem or question that cannot be answered through either art or science alone. Ideally, the experimentation, exploration and, possibly the analysis, will be done together. This certainly requires time and benefits from a curated space and a facilitator.

The academic debate that results from a group of persons trained in different fields of knowledge with different concepts, methods and data (Apostel 1972) may transform into an 'enduring and systematic scientific order that will change the outlook of subject matters and disciplines' (Mittelstraß 2011). This is the goal of transdisciplinary research. It takes the complexity of a situation into account and aims at understanding this complexity through a multi-angle approach. In transdisciplinary research, the interests of stakeholders matter when defining or framing the common problem, according to Christian Pohl, senior scientist at the transdisciplinarity network of the Swiss academies of arts and sciences. These may be unpredictable systems due to the multitude of factors and influences. Transdiscplinary research also deals with 'wicked' problems, which are problems in which: (1) every solution to a problem will be approved by some stakeholders and disapproved by others; and (2) every definition or framing of a problem also defines the possible solutions (Pohl 2021). Educational psychologist, Jean Piaget (Piaget 1970) adds that the 'interactions and or reciprocities between the specialised areas of research … locate links inside a total system without stable boundaries between the disciplines'. Durability, transformation of orientations and an engagement with non-academic problems are, arguably, key ambitions of of art-science collaborations. When examining artistic transdisciplinary studios, critic, editor, and professor of transdisciplinary studies, Alex Coles, questioned the very identity of disciplines themselves:

> But when a discipline has been contorted and expanded to such a degree through an artists' perpetual play with the language and contexts of other disciplines then surely there is no discipline to return to any longer – just frameworks that constitute contexts that are now outmoded. (Coles 2012)

According to philosopher of science, Jürgen Mittelstraß, transdisciplinarity is a scientific and problem-solving team-effort, as opposed to lying outside of scientific boundaries (Mittelstraß 2000). Despite this, I would argue that both inter- and transdisciplinarity penetrate the process of scientific discovery, which might be the greatest goal of art-science collaboration. The potential for awareness, a sense of awe

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and empathy, and adding the personal to scientific research is a vital part of exploration and discovery, yet it cannot be expressed by science alone. A remarkable aspect of human behaviour is our ability to generate new ideas from experience. Mark Rothko famously said that a painting is not a picture of an experience. It is an experience. So if we experience, through art, new connections emerge and reflection tuns into learning (Kolb 1976). Without this human aspect, the research is incomplete.

Art-science collaborations

According to philosopher, Uwe Voigt, there are three areas where (broadly speaking) interdisciplinary work operates: it can be established through common subject areas, methods, or cooperation (Voigt 2010). For many art-science projects, the point of contact is the subject area, which relates back to the notion of the artist being the external observer and the scientist who interacts with the artist as a form of teacher. Scientific concepts and findings are fertile grounds for creative minds and certainly one of the desired outcomes of such collaborations is to create art based on common subject areas. Some artists also adapt the methods of the scientist in developing a research practice. Most examples can be found in the experimental sciences where art-sci labs expand on, for example, biochemistry laboratories or material physics labs. Equally, observation-based research can be an integral part of artistic work. SciArt labs are environments that encourage experimentation, similar to a pure science lab, but to the degree that it encourages a creative process is similar to an art studio, effectively blending creativity, freedom of expression and (testable) analysis. It links testing and development of ideas and of questions to extract knowledge and to produce art. The concept of the 'trans-disciplinary studio' in the 'post-post-studio-age' is to experience 'a place where a large proportion of artists and designers generate ideas, objects, environments, and situations' (Coles 2012). It is the common grounds for theorists, scientists, artists, technologists, curators and architects working collaboratively on projects. Alex Coles continues in the introduction to *The Transdisciplinary Studio*:

> The amount of research undertaken in the studio makes no claims to the studio as a primary site for the production of the meaning of its outputs. If artists and designers continue to insist on requiring a studio … then shouldn't the way each of them mobilises it be a crucial component of any analysis of their practice? The place and means by which a work is generated — which, on occasion, has a hand in shaping its reception — must be accounted for. (Coles 2012)

It is much less common that a scientific lab adopts artistic methods, even though this could lead to increasing understanding of a given research problem, which is, in itself, a critical part of any scientific analysis and teaching practice. The third area in Uwe Voigt's list, that is, cooperation and the and the constructive constructive interaction of several experts by overcoming the narrow specialist boundaries

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(Warwitz 1974) is crucial to interdisciplinarity. Voigt writes that common subjects and methods are not the primary basis for interdisciplinary; they are not sufficient to create contact between disciplines (Voigt 2012). I would add that in cooperation individuals support each other with their individual goals. This is relevant and frequently implemented in ArtScience, including in the preparation of artwork or exhibitions and for outreach and public engagement. But this is not the the kind of collaborative work that a complex problem requires, if the shared objective is to solve such a problem.

James Elkins has created an alternative catalogue of theoretical models in which art and science can work together (Elkins 2017). The list is based on a conceptual analysis about art-science interactions. Of the eight classifications, the most common I have encountered in conversations with participants of art-science collaborations is related to 'Venn Theory', that is, the idea that art and science have a common ground. Roger Malina argues that there are more 'shared traits of personality and cognitive strategy' than differences between artists and scientists. (Malina 2006, quoted in Elkins 2017). I find common cognitive strategy occurs in contemplating a subject area and in experimental investigation, in understanding reasons for certain outcomes or thought processes. Both artists and scientists aim to make new information known or experienced and embed it in the current framework of the known. In addition, artists and scientists wish to have this received (and potentially, interpreted and discussed) with the hope that the outcome of their practice has an impact on the beholder. Edward Wilson expands on this arguing that the 'common property of science and art is the transmission of information … and the respective modes of transmission in science and art can be made logically equivalent' (Wilson 1998). In this way, artists and scientists meet as 'fellow explorers' (Roughley 2018).

From common ground to complementary ground

Scientific disciplines are often characterised by expert-thinking and the endeavour of objectivity. This notion is, of course, flawed or at least not sustainable since scientific research is conducted by humans — humans using data and technology, but humans nonetheless. As such, each decision the researcher takes is 'entirely bound to [their] domain of execution and [their] perspective' (Harvey 2021). Artists have often questioned science's claim to objectivity. For example, in *3 stoppages-étalon [3 Standard Stoppages*] (1913-14), Marcel Duchamp created (supposedly objective) measuring yardsticks that changed according to the natural occurrence, thus Duchamp 'uses chance ironically, to critique … and specifically does this by using a nonrecurrent procedure to stand in for the natural world that is supposedly being "measured"' (Hosking 2019). Artistic disciplines are associated with subjectivity: art can throw light on political issues, can be socially engaged, opinionated and call for reformation. This is vital for an open debate in times when 'the concept of ethics, justice, equality and democracy have never been so elastic' (Volz 2019). Through the alarming rise of science denialism, historical revisionism

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and manipulated truths, the freedom of art and science and their complementarity are essential for our interpretation and value of the world we live in and the ways we understand and learn.

In addition, there is a time where the scientific process and the art creation process are very similar. New knowledge (in contrast to repeating the learned) starts as an intuitive, first-person perception (Krakauer 2019). Those earlier phases are often missing in the large-scale or institutional production of science and can be found in art and science collaborations that share a common goal.

In their book, *Data: a guide to humans*, Phil Harvey and Noelia Jiménez Martinéz write that using data — the core tool for scientific exploration — 'represents a fundamental shift in human epistemology' (Harvey 2021); a change in how we know things. Though integral for knowledge production, data is not the only way we understand. Experiencing art can lead us to feeling things. The role and integration of areas in the brain related to higher meaning or knowledge is not well understood in neuroaesthetics (Chatterjee 2014). However psychologist Matthew Pelowski writes about art perception in the brain:

> Beyond basic vision and judgement, art viewing is notable for its unique blending of bottom-up processing of artwork features (form, attractiveness) with top-down contributions of memory, personality, and context. These are further united with even higher-order, complex, and often effortful cognitions whereby we respond to our initial reactions, discover complex meanings, novelty, and make judgements. (Pelowski 2017)

This might explain why interaction with art is often both challenging and rewarding. The top-down contributions of memory, personality, and context can explain 'how individuals adapt or change within their processing experience, and thus how individuals may come to particularly moving, disturbing, transformative, as well as mundane, results' (Pelowski 2017). Experience is a way to wake up and see '[w]hat you feel, you can do', as artist Victoria Vesna plainly stated during a panel discussion organised for the exhibition 'Our Place in Space' (Vesna 2018). SciArt collaborations can thus be thought of as complementary knowledge systems.

Given these insights, could art and science collaborate to help solve complex problems, where a solution is not obvious? Research by Professor in Human Social Dynamics, Mirta Galesic, and collaborator, Daniel Barkoczi, shows us that we do not optimally solve complex problems in very well-connected or large groups. Rather, the way we integrate information in moderately-sized groups makes it successful (Galesic 2016, Barkoczi 2016). They further explain that during the first stage of a decision-making process, where information is collected, a network benefits from maximal diversity, that is,

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diverse origins of understanding and opinions. Art and science span the entire spectrum, as Professor of Complex Systems, David Krakauer, puts it, from the the maximal random (the arts with individual expression) to the maximal regular (the sciences that favour compactness and few free parameters) (Krakauer 2019). However, just being exposed to 'the other' will not guarantee a better outcome. I argue that in order to integrate social information, group members need to confront their prejudice and biases towards the other discipline.

Art experienced as meditation is a powerful gateway to personal reflection and can be a break-away point to turn science into art; into an experience; into a learned knowledge; into action (see also, Kolb 1975 and Billett 2011). This sequence starts with reflection, which according to Professor of Work-Based Learning, Ruth Helyer, is 'associated with "looking back" and examining the past in order to learn from what happened' (Helyer 2015). Learning is also connected to reflecting on action (Schön 1983). This may be initiated through interactive art where the beholder becomes an active part of the artwork. Reflection evoked through an artwork encourages an exploration of thoughts and feelings, 'looking for insights, and maximizing on self-awareness which all tie the process closely to identity formation' (Lacan 1977, quoted in Helyer 2015). This can also be connected to awareness of some 'trigger', inducing reflection on the self (Pelowski 2017) and leading to a personalised 'experience-based' interpretation, whereby the impact and meaning of an artwork is based on the previous experience of the beholder, independent of the artist's intentions (Dewey 1980).

Scientists involved in art creation can experience art (and art-making) directly linked to the problem they study, including their previous experience and research. This can uniquely effect their reflection, insights, and learning processes. Knowledge production or ideas that are based on the 'diverse behavioural and cognitive impacts of art' (Pelowski 2017) are underused opportunities for scientist. Note, however, that learning from art is not unproblematic: following John Dewey's argument for desired results from art, beholders might merely fill a dead spot in experience, desiring continuity and organisation of experience (Dewey 1980).

How then can we judge the success of art-science collaborations? Which output is the measure of the success of the process (studio-based? lab-based?)? What is the product of a collaboration between artists and scientists: knowledge, understanding, artwork? How knowledge is conceived may be different for the artists and the scientists, so a standardised measure is likely unattainable. Success could mean the identification of a cross-pollination of knowledge and ideas or a product, such as a work of art. This can then made available to others in an appropriate setting. Showing the ArtScience artwork in a gallery or museum has measurable benefits:

10.3 The Value of ArtScience

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> Entering a museum has been shown to prompt a certain mode of viewing … encourag[ing] individuals to expect and respond positively to surprises or challenge, as well as to show more interest, find an object more arousing, and engage more fully with art. Alternatively, expectations that one will engage in more of an everyday or 'real life' situation can prompt a 'pragmatic' mode, where individuals give more focus to meaning, content, and importance or relation to the self. (Pelowski 2017)

Perhaps success can be connected to meaning-making. In 'Vienna Integrated Model of top-down and bottom-up processes in Art Perception (VIMAP)', psychologist Matthew Pelowski and colleagues summarise the default interaction with art as a basic identification of the main formal features or a simple assessment of visual appeal or recognition, including an egotistical connection to the viewer, which is often found with children and lay viewers (Parsons 1987). Pelowski's example for this is: 'This character looks like my cousin'. This basic processing may also relate to semantic meaning or to a wider historical or contextual context without finding something new, without seriously questioning and changing conceptions or the self. Other types of perception identified by the model is when people have insights or when we experience harmony, flow, emotional resonance and self relevance. This 'may reflect a powerful, but inexpressible type of experience-based meaning' occurring when the artwork 'resonates particularly with a viewer's identity'. It can even lead to transformation, which would imply a change at a core aspect of the self. These latter outcomes of processing art are usually connected to a period of intense interaction with the art and an ArtScience collaboration could facilitate such engagement. I found that guided translation between the two disciplines and dedicated time and space are necessary to allow engagement, exploration and interaction with the ArtScience and its process.

Of course, not all interactions with art are positive. However, negative or even hostile reactions, where we can expect the loss of understanding, have been shown to correlate with low art knowledge and interest (Pelowski 2015). This circles back to and strengthens the argument that a successful (that is, satisfactory) collaboration between scientists and artists requires knowledge and interest in the both disciplines, specifically the willingness for the scientist to spend time with, and on, the artwork, acquainting themselves with art.

ArtScience does not explain the science. It is not science visualisation. Nor is it (usually) illustrative. Rather, ArtScience allows people to experience, to understand, to act. We respond to art individually based on our unique experiences; our own cultural and historical background completes the artwork. Without a scientific goal, the artist is free to approach the material with as much or little complexity as they wish. In contrast, science (attempts to) produce and deliver science in a stripped-down, sobering

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way, independent of the human, cultural or personal background of the scholar. Scientists must strip science of personal and social context to reach conclusions. Art can thus provide a slap-in-the-face, high-pitched wake up call that is rarely available to science. It has the unique power to add individual value and personal meaning to scientific data, which can lead to new knowledge and can help to solve complex problems that challenge our ability, particularly where a solution is not obvious.

Notes

[1] The University of Hertfordshire's annual Theorising Visual Arts and Design Research Group symposium's emphasis on art and science collaborations is tangible evidence for this trend. Several participants work in groups that unite fine artists, researchers and technologist in an academic setting. Examples are the Cultural Negotiation of Science group at Northumbria University and the Plymouth College of Art's Making Futures research platform. Other examples include the research focus on transdisciplinarity of the Zurich University of the Arts, the University of California Davis Art Fusion programme, the National Science Foundation's (NSF) projects, the Transdisciplinary Research Program at the Korea Institute for Advanced Study, the Institute for Cultural Inquiry (ICI) Berlin, and the University of Western Australia's dedicated art and science lab 'SymbioticA', and the 'Hybrid Plattform' of the Berlin University of the Arts and the Technische Universität Berlin.

[2] These are the questions raised in the provocation for the symposium: https://www.herts.ac.uk/researc and-units/tvad-theorising-visual-art-and-design/tvad-symposium.

[3] I do not agree with the concept of a hierarchy of disciplines, since it is based on a highly subjective and arguably outdated ranking based on some perceived idea of what might be more useful.

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10.4

Porous Bodies, Toxic Kin: Mapping the Massena Critical Zone

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Lisa Taliano and Maria Patrica Tinajero, USA

Porous Bodies, Toxic Kin: Mapping the Massena Critical Zone

Fig. 1 Digital Photograph. Landfill (Alcoa, Massena, NY), 2020. Photo courtesy Maria Taliano. This image is from an active landfill.

Mapping the Massena Critical Zone (MMCZ) art research project emerges from personal injuries and the desire for environmental health and justice. The MMCZ has become a discovery process that resembles that of Penelope, queen of Ithaca, who spent years weaving during the day and unweaving her loom during the night. An epistemological read, of weaving and unweaving as a process, bears multivalent meaning for our project. For one, it can be understood that during the day, we are weaving the poetic narratives of artistic representations and ecological urgency, while at night, we are unraveling the politics and black boxes that make science. The unraveling of the thread is no longer a trick for an idled wait, it is a way to recognise patterns for finding new knowledge on the one side and working together and sharing it on the other. The weaving motif falls in line with Donna Haraway's situated knowledge (Haraway 1988) and her comparison of the collaborative method to a game of cat's cradle (Haraway 1994).

> Cat's cradle invites a sense of collective work, of one person not being able to make all the patterns alone. One does not 'win' at cat's cradle; the goal is more interesting and more open-ended than that. It is not always possible to repeat interesting patterns, and figuring out what happened to result in intriguing patterns is an embodied analytical skill. (Haraway 1994, 70)

Porous Bodies, Toxic Kin: Mapping the Massena Critical Zone

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Thus, in times of economic and environmental turmoil, our artistic practices engage with new creative interdisciplinary social/science practices based on collaboration and research. Stephen Wilson in *Information Arts: Intersections of Art, Science, and Technology* (2002) remarks on the necessity for extending the reach of research to the arts, Wilson writes that '[i]f the research is going to help write the culture's future, then the culture needs artists to help in the writing' (Wilson 2002, 11). Blurring the boundaries of knowledge is inevitable. Wilson goes on to say that 'it seems incontrovertible that neither artists nor scientists can stand completely outside of a cultural or economic milieu...Together they make a full picture of what the research really is and what it could mean (ibid, 50).

Our collaboration opens up our conventional creative practices of painting and sculpting by thinking with and through Polychlorinated Biphenyls (PCBs) [1]. From this open approach we develop methods to connect, support and maintain the links that tie us to the more-than-human worlds in an ethical exchange. [2] It has taken us into uncharted territories, traversing some friendly disciplinary borders and some hostile bureaucratic landmines. The different territories of knowledge often are at odds with each other and are constrained by authority and the power of money. Crossing over traditional demarcations between art, science, and politics [3] is an inherent part of collaborative environmental practices, ecological art, and art and social justice practices (Frances Whitehead 2008, Beth Carruthers 2006, Linda Weintraub 2006, 2012). In this essay, we will first present the theoretical and philosophical concepts that situate our project at the juncture of art, science, and politics. Then we will describe the fieldwork and research of the MMCZ project thus far.

The concepts we develop for the project are a creative interpretation of Bruno Latour's concept of the critical zone in combination with Stacy Alaimo's trans-corporeality. For Latour, the critical zone is both a site and a science. As a site, it is the thin, fragile skin on the earth's surface where all life exists. As a science, it is a new multi-disciplinary earth system science that takes post-structural theory seriously. The critical zone is critical, as a site, because it is endangered. It is also critical, as a science, because it is a scientific zone open to post-structural theory (Latour, 2014). That is, it does not make claims to traditional western science's universal objectivity. As Bruno Latour observes, scientists do not discover facts, they make them (Latour, 2020). Trans-corporeality is a way of decentring the human and undoing the impermeable western human subject through an analysis of the critical zone as the interpenetration of porous bodies.

The problem of pollution (the leaching of PCBs) in Massena has been going on for a long time,

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but it was only through collaboration and the conceptual framework that it became attackable and manageable for us. The critical zone and trans-corporeality gave us ways to wrap our heads around the complex and dynamic situation surrounding the contamination, providing us with alternative ways to talk and think about the challenges of illness, toxicity, pollution, and death. Remapping porous bodies in terms of their relations gives us a clear picture of what is required to change our relationship to the environment, to recognise our bodies as enmeshed with the animate world. The challenge is for us to resist separating our flesh from the flesh of the earth, to find ways to think about the world that doesn't detach the observer from the observed, science from politics, and nature from culture.

In the field work and research of the MMCZ project, we assume two positions: as citizen scientist and as artist researcher. Through the practice of the citizen scientist, we foster a political awareness between science and capitalism. As artist researchers, we introduce experiential perspectives to investigate the connection between our health and the environment. Our unorthodox role as researchers and subject, or object of research, has complicated the process, especially given that we are not public health experts, nor trained scientific researchers; it has been a learn-as-you-go process as we co-create new, more transformative practices and actions. Collaborations in art belong to a growing body of creative research and artistic practices that propose meaningful communication and open participation. It emerged under different models and approaches, including socially engaged art (Nato Thompson, 2012), participatory art (Claire Bishop, 2006), and relational aesthetics (Bourriaud 1998). Collaboration assists not only with the blurring of disciplinary distinctions but also challenges the hierarchical structures of hegemonic and patriarchal models. MMCZ artistic research advances collaboration by means of Alaimo's trans-corporeality to explore the porous condition of bodies as a twofold strategy. First, we understand all bodies as interlocked and interdependent in their dynamic interactions. By bodies here we mean all social, economic, scientific, and political bodies, as well as the material bodies that cross through and transform us. Secondly, we employ trans-corporeality as a placed-based strategy; a critique of the universal and objective authority of science (Murphy 2021, Latour 2020) which creates the conditions that bring about environmental violence. Although we are all affected by chemical pollution we are not all affected equally. The uneven distribution of power and exposure demonstrates one's situatedness. The purpose of this placed-based trans-corporeal mapping is to make this situatedness and injustice clear. In so doing, we hope to enable the emergence of collective agency, by opening the collaborative process to include members of the community, to challenge the dominant discourse of universal objectivity, and to create new narratives, with new forms of subjectivity, ones that recognise body/land relations as primal. Alaimo writes:

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> By the early twenty-first century, we can no longer take refuge in a vision of science as an objective, separate sphere of knowledge making, but rather we must recognize and grapple with its entanglements … For feminist epistemologists, postcolonial epistemologists, and others who have long critiqued Western scientific models of objectivity, this shift may be an opportunity to transform science into something more accountable, more just, and more democratic. (Alaimo 2010, 65)

Western Science, Indigenous Knowledge and The Critical Zone

In mapping the interactions between entities that make up the environment in Massena, intricate and differentiated relations of the critical zone and culture/politics emerge to underscore the importance of acknowledging the connection between the physical world and different ways of knowing; this is palpable in the different responses to the cleanup of the contaminated sites. The cleanup efforts in Massena are distinct from those of their neighbours, the Mohawk Tribe of the Akwesasne Reservation situated downwind and downstream of the polluters. Unlike the people of Massena, the Mohawk Tribe fought against the corporations and the US government for complete remediation of the contaminated sites. We will elaborate more on this disparity later in the essay. A renewed attention by New Materialist Feminist thinkers and Environmental Phenomenologists to learn from traditional oral cultures, indigenous and First Nation people is helping to shift how we engage with the material world. Some indigenous cultures see the land as animate, sacred and it is not something a person can own. The land does not belong to people, people belong to the land, and it is their responsibility to honour and protect it (Abrams 1996, Wall Kimmerer 2015). This world view is in stark contrast to the western scientific approach of knowing the world, promoted by capitalism, that sees the earth as inert matter, a resource that can be exploited for human consumption and profit. It is worth noting that within a few centuries of European settlers arrival in North America, the colonialist project had destroyed much and irreversibly altered the land.

The re-mapping of the critical zone is a means to define, enter into, and manifest new worlds (Law 2015, 2); worlds that reject objectivity, universals, and bounded individuals as given outside of reciprocal relationships. Re-mapping borders where our bodies are porous does not mean a re-drawing of lines or an outlining of objects, bodies and land masses. It is a re-making of relations, between bodies and between people.

Chemical Kinship and the Porous Body – Thinking through PCBs

Bodies are agents that connect and situate our various shared experiences and heterogeneous knowledges through affective responses. Our traditional artistic practices explore the connections

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between porous bodies from a pre-theoretical position. For example, Lisa Taliano's painting *Becoming Animal* [Fig. 2] is an aesthetic response to the tragic losses experienced as a result of the effects that PCBs have had on our bodies. In this painting, the figure-ground relationship collapses, while the interactions between colours and forms suggest a trans-corporeal flow of matter that entangles and changes the porous bodies that overlap each other within the pictorial frame. *Becoming Animal* is not a representation that illustrates porous bodies, it is an affective response to PCBs' free circulation that passes through, and in many instances stays within, the land and our bodies: 'the human body is radically open to its surroundings and in constant interchange with its environment, making it impossible to separate the two' (Alaimo 2008, 255; 2010, 13).

In a similar approach to Alaimo, Science and Technology theorist Michelle Murphy recognises the porous nature of bodies as fundamental for understanding our physical relationship to the environment. Just as you cannot understand individual bodies in isolation, Murphy points out, it is equally true that you cannot understand chemicals in isolation, as western technoscience tends to do (Murphy 2021). By stripping them of their relations and understanding them in their universal properties as isolated molecules, the effects they have on our bodies, the environment, and each other are erased. Murphy points out that when we understand chemicals in all their relations, not just as isolated molecules, we come to understand that when we breathe in PCBs we are not just breathing in a molecule, we are breathing in the chemical infrastructure that produces and circulates them (Murphy 2021). Given that PCBs are endocrine disruptors, our bodies are now molecularly bound to the chemical's manufacturer, Monsanto [4]. Murphy uses the concept 'chemical kinship' to understand this intertwined deadly relation as bringing us into a 'filial relation' with the chemical giant (ibid). This familial relation gives us the right to insist that the company recognises its obligations and takes responsibility for its role in altering our bodies and our world.

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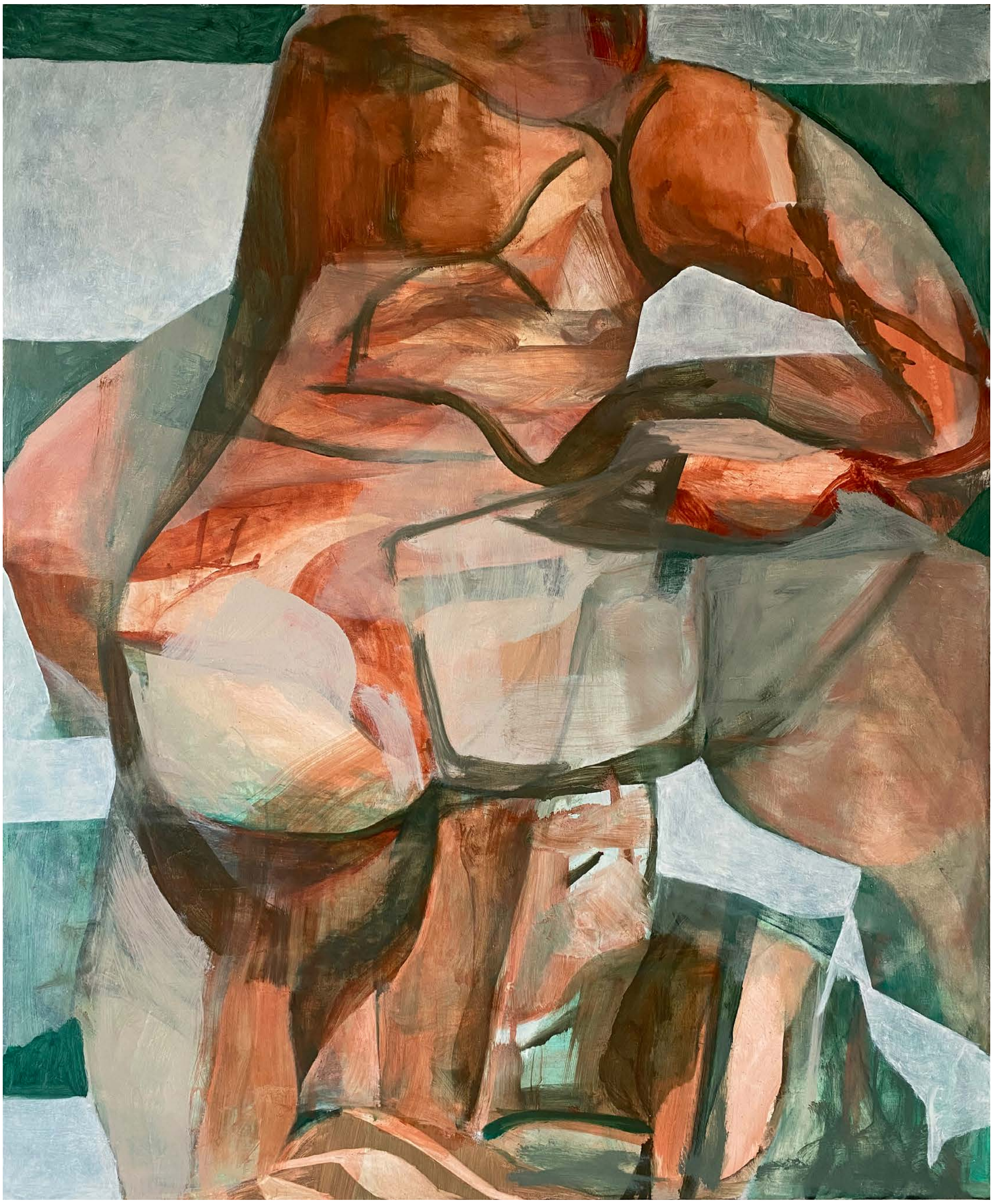

Fig.2. *Becoming Animal*. Oil on Canvas. 2020. Dimensions 48"X60" (121cm x 152cm) Image courtesy of the artist.

Thinking through PCBs maps the Massena Critical Zone in a kind of cartographic account of the complex power relations that produce the environment in which our bodies are an extension. It is a remapping of boundaries between subject and object, nature and culture, biotic and abiotic entities, as PCBs produce new human-non-human linkages, binding us to each other, to our environment and to the 'chemical infrastructure' (Murphy 2021). In this sense, MMCZ can be seen as contributing to

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the process of undoing the human, and becoming post-human subjects [5], creating new forms of collective subjectivities as the material interchanges between bodies of a specific place become the site for ethical-political engagement.

In investigating the Massena Critical Zone, we look for scientific methods of understanding chemical exposure beyond the individualised body to recognise and honour the inseparability of bodies and land and to confront our expansive relations to PCBs as they entangle our bodies in political, economic, and cultural relations 'bursting open categories of organism, individual, and body to acknowledge a shared, entangling, and extensive condition of being with capitalism and its racist colonial manifestations' (Murphy 2017). We trace the trans-corporeal movement of PCBs from their production by Monsanto, to their use and misuse by the industries in Massena, through the contamination of the rivers and our bodies, by way of the material, political, economic, and cultural systems that circulate them.

Massena is a working-class town settled by European immigrants at the turn of the last century, drawn to this remote area in the northern New York wilderness by the power of the St. Lawrence River, harnessed by industrialists to produce cheap electricity for the energy intensive process of smelting aluminium. The Aluminum Company of America (Alcoa) planted itself there in 1903, becoming the economic driving force of the town's expansion. Alcoa not only provided jobs, it also built homes for the newly arrived immigrants and had a major role in defining the culture of Massena.

The land on the St. Lawrence River where Massena resides is the ancestral homeland of the Mohawk, one of the six nations of the Iroquois confederacy that originally inhabited what is now New York State. After the revolutionary war, the US forced the Mohawks to cede their lands, pushing them into Canada. At which point, New York State illegally sold off five million acres of former Iroquois land at very low prices, seeking to attract settlers to develop it for agricultural and industrial purposes. The Mohawks that remained in Northern New York were forced onto the St. Regis Mohawk Reservation, also known as Akwesasne, which borders Massena to the east. The attacks on the land continued with the construction of the Robert Moses Power Dam on the St. Lawrence River which, in 1958, flooded 15,000 acres of traditional territory used by the Mohawks. They were not consulted or compensated for their losses. On the contrary, the power dam increased the supply of cheap electricity in Massena attracting companies like General Motors and Reynolds Metals to build factories there; companies whose operations would contaminate the rivers, land and air, poisoning the Mohawks who lived on the reservation which was situated downwind and downstream from the facilities.

The three companies of Massena, Alcoa, General Motors, and Reynolds Metal, indiscriminately

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released toxic contaminants into the environment from 1958 to 1984. When the news of the contamination broke, in the late 70's, the people on the reservation mobilised and tenaciously fought the government and corporations for remediation and retribution (Hoover 2017, Brennan 2016). Whereas, the town officials of Massena sided with the polluters and worked to silence community members who spoke out against the companies. The companies themselves denied responsibility until they were finally found guilty by the State and Federal government which designated them as 'Superfund Sites' [6], listing them on the National Priority List for cleanup.

To this day, the people of Massena were never properly informed of the extent of the contamination and the health hazards of PCBs. It has been relatively easy for the local government and companies to downplay the disaster since PCBs are imperceptible and there is a latency between exposure and health effects. People suffered and died prematurely from unusual occurrences of diseases without knowing why. Even if they suspected the cause, there was no way to prove it. The men who worked in the pot rooms and the people who lived in the low-income neighbourhoods close to the polluting facilities were more likely to be diagnosed with cancer and less likely to be taken seriously by elected officials and corporate representatives; they were easily coerced into silence. Without the political will of the town and the support of the community, people who suffered remained isolated and left to fend for themselves, oftentimes lacking access to adequate healthcare.

We took up this research project in the light of the recent revelation of Monsanto's deliberate deception of the health effects of PCBs, and the growing awareness of the people of Massena that many of the ailments and diseases that they suffer from are known to be linked to PCBs. We launched this project with the intention of conducting an empirical study which would collect data on PCB exposures, blood levels, and health effects, to definitively demonstrate what we all know to be true: PCBs are a form of environmental violence that result in ongoing human suffering. In order to assess the feasibility of our project, the first phase of our research included interviews with stakeholders including the people of Massena, local government officials of the town of Massena, New York State (NYS) Department of Health and NYS Department of Environmental Conservation officials, Public Health specialist working on the effects of PCB contamination on similar populations, representatives of the Tribal Government of the Mohawk Nation, and Akwesasne. In addition to interviewing citizens and environmental and public health officials over the last two years, we have tracked down, collected, and begun analysing the vast amounts of information that currently exists on the Superfund Sites in Massena, along with the medical research on the health effects of the contaminants released. In doing so, we have identified what appears to be gaps in the data, especially in relation to the disconnect between the environment and our bodies.

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Mind the Data Gap – Citizen Scientists

The data gap that we've encountered prevents us from pinning down the facts. It creates a disconnect between the published scientific data and the evidence from our own experience. Whereas some data appears to be deliberately used against us, other data is incomplete and outdated due to the limitations of our government officials. Four aspects of the data gap encountered include: 1) lack of scientific research 2) outdated information 3) inaccessibility of information, and 4) misleading information.

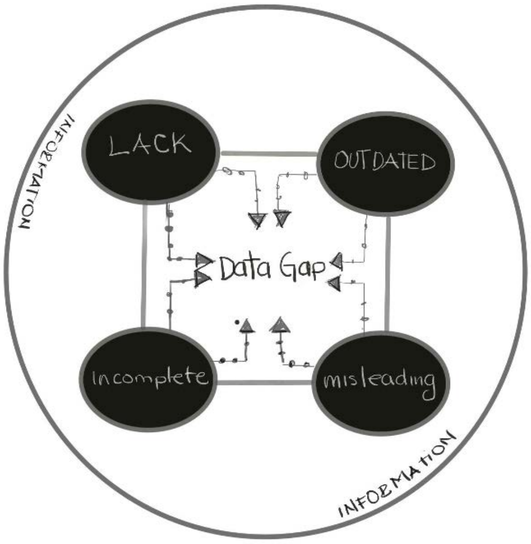

Fig. 3 *Mind the Data Gap*. 2021. Digital Image. Courtesy of the authors

What follows is a brief account of some of the issues we've encountered:

- It is virtually impossible to get tested for PCBs. The CDC website says 'Serum PCB tests are readily available at most commercial reference laboratories'.[7] Nevertheless, we have run into many obstacles trying to find a way to measure the levels of PCBs in our bodies.[8]
- The Agency for Toxic Substances and Disease Registry (ATSDR) publishes Exposure Standards and Regulations such as the EPA's maximum contaminant level (MCL) for PCBs in drinking water and the FDA's tolerance level for PCBs in food. These standards are based on the assumption that the more the chemical the worst the effect, implying that it is the dose that is poisonous, not the chemical. Experiments are designed based on that assumption, looking for the threshold where a chemical starts to produce a negative effect (Murphy 2021). The idea that for every chemical there is an amount you can do, where it's not a problem, implies that we can pollute up to a certain point before it's a problem. However, as Michelle Murphy points out, this is a setup when it comes to the endocrine disrupting chemicals, such as PCBs, because some of the strongest effects happen at the lowest doses.

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- The burden of proof is placed on the public, who lack resources and knowledge to produce a scientific valid proof. For years after the contamination was discovered, we were told that PCBs primarily enter our system through the food chain. The solution to avoid harm from contamination was 'not to eat the fish'.[9] However, as has been recently revealed, Monsanto knew as early as 1949 that PCBs were 'definitively toxic' at 'such low concentrations' it was important to take great care to keep concentrations in the air at extreme low levels, because the 'Prolonged exposure to Aroclor [PCB] vapors will lead to systemic toxic effects' (M&R, 2018, 496).

What follows is a brief account of some of the issues we've encountered:

	Inaccessibility of information	Misleading information
Outdated Information	Websites: DEC, DOH, EPA and CDC are challenging to navigate making it difficult to find relevant data. Oftentimes links to reports are broken returning 'page not found' errors.	Outdated and inaccurate information on an official government website gives misleading information. The CDC Biomonitoring site https://www.cdc.gov/biomonitoring/index.html states that PCBs are 'classified as probable human carcinogens by IARC' whereas the IARC changed their classification from 'probable human carcinogens' to 'carcinogenic for human beings' in 2013. At the bottom of the CDC page where it publishes this incorrect date it says 'Page was last reviewed: April 7, 2017'.
Lack of Information	The New York State Cancer registry is seriously flawed because it doesn't take into consideration that people move. Most people who grew up in Massena at the time of heightened exposure (1960-80) have left the area. This is a serious problem since oftentimes the effects of PCBs don't appear until 20 years later, which means the people of Massena who move to another state become statistics in their new state. The red tape resulted from unsuccessful encounters with public servants. People not returning calls or not knowing information or being unable to direct us to someone who did.	ATSDR in conjunction with EPA determine maximum contaminant level (MCL) for PCBs in drinking water. This is misleading for endocrine disruptors. The FDA determines tolerance level for PCBs in food, but companies are not required to label. Because food is not labeled, we don't know when food contains PCBs.

Our studies reinforce the idea that the erasure of chemical pollution and environmental violence is built into the ways data is collected (Murphy). Nevertheless, despite that data can be used to gaslight and manipulate us, it can be useful as long as we understand its limitations and how it works. The data gap makes it clear to us that we need to conduct our own research, and share that in a way that is meaningful and accessible to the community.

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For example, see Dr. David O. Carpenter's tree bark experiment. Dr. Carpenter is a Professor of Public Health and the Founder of the Institute for Health and the Environment at SUNY Albany. He has been studying the effects of PCBs on the Mohawk Tribe for the last thirty years. In an interview with us, he described how his research group was experimenting with methods for testing the presence of PCBs in tree bark in order to measure their volatility level [10]. We see this kind of experiment as one that could greatly benefit from a more open collaboration with citizen scientists, helping place the data sensors to collect the information. The trees, the scientist, and the citizen scientist can weave new stories to resist the powerful process of contamination. When we shift our narrative, we can recognise that the authorities do not have everything under control. Thus, the need for opening research and engaging in collaboration as a more democratic endeavour that allows sharing in ways that are more accessible to the public, which in return encourages better understanding and a sense of ownership to stop corporate entities from polluting. When data collection on pollution becomes a civic duty, then it will be evident how chemicals in their extensive relations shift our sense of self. We see how we are interconnected with the vast biological, economic, and industrial systems in which we are enmeshed. By refusing the opposition between objective scientific knowledge and subjective experiences we put ourselves in a position to remake science with the values that we care about.

The problem with the data gap is not just about missing data, but about the quality and nature of the scientific data collected and its erasure of relations, its claim to universal objectivity. We need to complement scientific data with emotional accounts and experiential information. We've learned that without money, resources and institutional backing, it's virtually impossible to conduct standard chemical analysis on the effects of pollution on human bodies. However, we have also learned that proper research and collection of data can be conducted indirectly by following the traces left by the chemicals, that is, by collecting stories. This rich, untapped reservoir of knowledge and information is where we continue to work, incorporating Science Technology and Society (STS) strategies for research, and collective activism. This method entails working directly with the people of Massena. The goal is to extend the bonds with all the stakeholders so that we can formulate questions that are specific to this case study to foster community-making and value-sharing.[11]

Closing the data gap can be seen as a game of cat's cradle with the community to narrow disparities by engaging the people of Massena in an open collaboration, through a grassroots participatory epidemiological study. This model brings data and people together by collecting stories and engaging with the people on equal footing. As subjects, the people of Massena are not just an object of study, but the subjective force that drives the effort to confront pollution. In this participatory collaborative effort, science becomes more visceral by interweaving self, history, culture, economics, and power. It can

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challenge and change the dominant discourse through new narratives that move us from individual to collective agency, allowing participants, as well as researchers, to cope with our grief and loss, and to proceed to healing, remembering, and resisting.

Minding the data gap is in a process of collecting information, both quantitative and qualitative, and its visualisation, analysis, and distribution. It is a titanic task that must be done as a collective effort. Artists can also contribute to minding the data gap from aesthetic positions by visualising not only statistical models but through low-tech low-budget initiatives that tackles the problem in unexpected ways. For example, Tinajero's piece *Body Journal* (2001-2014) [Fig.4] narrows the data gap by going beyond statistical analysis that interprets data and explores the convention of art and science through the permeability of bodies using cotton pads as a low-tech biometric collectors of air pollution. The cotton pads collect samples when the artist cleans her face after a day of activities in the city. They collect the accumulated residues of air particles deposited on her skin to set the stage for a conversation with the soot, dead cells, chemical volatile particles, pollen, and dirt. It is, to paraphrase Whitehead (2018), a provocation to see beauty as a tool to make visible the effects of air pollution.

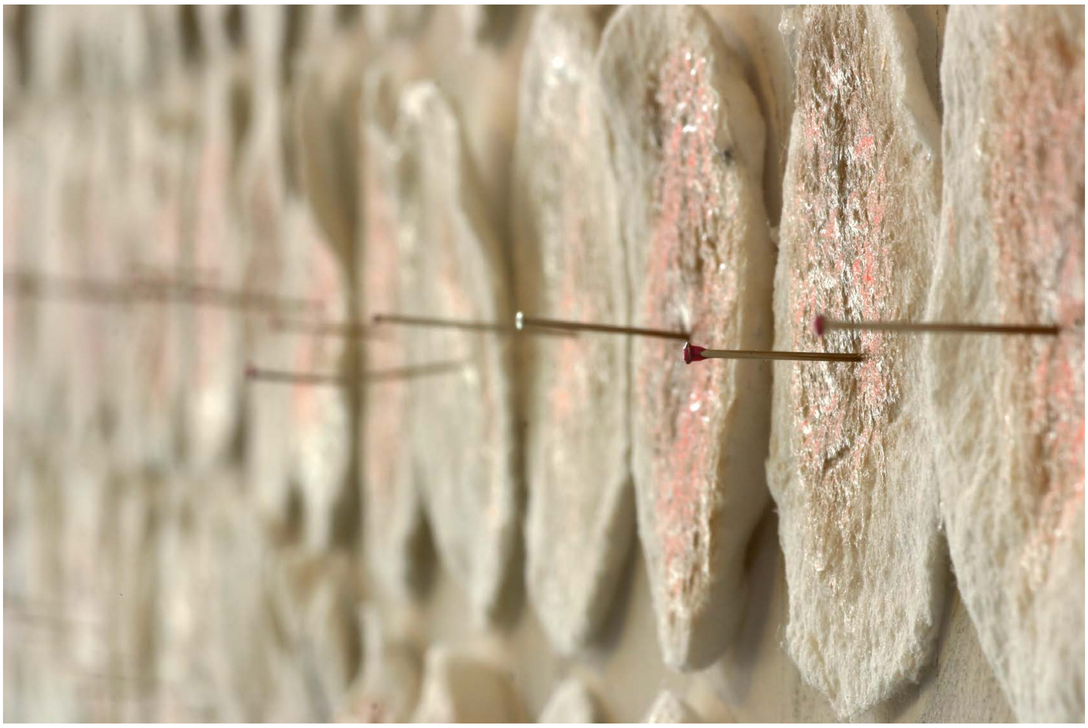

Fig.4. *Body Journal* (2001-2014). Private Collection. Wall sculpture shows 270 days of sampling. Image courtesy of the artist.

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Conclusion

PCBs are pervasive: there is not a place on the planet that wouldn't test positive for them, or a human body that doesn't have them in their blood [13]. They have entered our system, and we have become molecularly altered by them (Murphy 2017, 496). By minding the data gap, the invisible interconnections between the biological, economic, and industrial systems in which we are enmeshed are revealed to us. We must be methodical and persistent as citizen scientists and artists activists in this effort to find creative ways to engage in solidarity and collective action as we come to terms with the damage inflicted upon us and the environment. Irreversibility is a condition that prevents us from recovering what is lost, but, at the same time, it also acts to bring us together to make the connections in art and science that solidify the collaboration we need to imagine new ways of adapting while also bringing forward possibilities for the future rather than living in despair.

Illustrations

Fig 1. Digital Photograph (2020). Landfill (Alcoa, Massena, NY). Photo courtesy Maria Taliano. This image is from an active landfill. The chain-linked fence is a visual reminder of the boundaries that, on the one hand, act as a lame attempt to protect the surroundings from the buried chemicals with a futile barrier that cannot contain and separate the toxic chemicals from us. And, on the one hand, it can be seen as a metaphor for the porous nature of the different fields of knowledge of which we are engaged. Crossing over traditional demarcations between art, science, and politics is also like stealing through the openings of the fence.

The distance from the fence to the Alcoa landfill in Massena plays with depth of field so that the landfill is out-of-focus. Landfill embodies the sentiment of impotence where fuzziness takes over clear thinking when we confront the extent of the environmental problem at the site.

Fig 2. *Becoming Animal*. Oil on Canvas. (2020). Dimensions 48"X60" (122 x 152cm). Image courtesy Lisa Taliano.

Fig 3. *Mind the Data Gap*. (2021). Digital Image. Courtesy of the author

Fig 4. *Body Journal* (2001-2014). Private Collection. Wall sculpture shows 270 days of sampling. Image courtesy Maria Patricia Tinajero.

Notes

[1] PCBs are a chemical manufactured by Monsanto Corporation from 1930-1977 and 'designed to be resistant to chemicals, heat, water, and to be virtually indestructible' (M&R 2018, 466). Due to their high boiling points and strong resistivity, they were used as coolants and fire retardants,

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in industrial processes, electrical equipment, and innumerable household products such as adhesives, paint, carbonless copy paper, ink, insulation, shower curtains and chewing gum.

[2] Artists working at the intersection of art, science and technology are growing in number. We would like to mention Meghan Moe Beitiks and how she works with associations and disassociations of culture/nature/structure, analysing perceptions of ecology though the lenses of site, history, emotions, and her own body to produce work that examines relationships with the non-human. https://www.meghanmoebeitiks.com/about/

[3] Artist Claire Pentecost remarks that '[i]f the artist aims to make an impact on the use of science and related biotechnologies to concentrate resources in the hands of a very few, she must refigure both scientific and artistic practice'. 'When Art Becomes Life', *Transversal Texts*, 2007, transversal.at/transversal/0507/pentecost/en.

[4] In 2018, an enormous trove of previously private Monsanto documents was released as the result of a lawsuit waged by government agencies on the West Coast against Monsanto seeking funds to cleanup PCBs in their ports and waterways. These documents reveal that Monsanto was aware that PCBs were systemic poisons, dangerous to the environment and human health as early as the 1930s. Cecil Drinker, Professor of Public Health and Medicine and Dean of Public Health at Harvard University, in 1938 wrote a private report to the Monsanto Chemical Company that pointed out that some chlorinated biphenyl compounds were 'so definitely toxic' at 'such low concentration[s]' that 'it seems imperative that whenever this compound is used in industry, great care be taken to keep concentrations in the air at an extremely low level. No liberties can be taken with it' (M&R, 2018, 469).

[5] As defined in R. Braidotti. 2019, 'A Theoretical Framework for the Critical Posthumanities'. *Theory, Culture & Society*. 36 (6) : 31-61. doi:10.1177/0263276418771486

[6] The United States Environmental Protection Agency (EPA)'s Superfund program is responsible for cleaning up some of the nation's most contaminated land and responding to environmental emergencies, oil spills and natural disasters. To protect public health and the environment, the Superfund program focuses on making a visible and lasting difference in communities, ensuring that people can live and work in healthy, vibrant places. https://www.epa.gov/superfund Accessed 29 Dec 2021

[7] See The Agency for Toxic Substances and Disease Registry (ATSDR) Environmental Health and Medicine Education https://www.atsdr.cdc.gov/csem/polychlorinated-biphenyls/ assessment.html

[8] There are laboratory tests that can measure PCBs levels in fat tissue and blood serum but it's virtually impossible to access. Oncologist, Gynecologist, General Practitioner, and Surgeon at NYU, one of the leading Medical Institutions in the United States, could not prescribe the test. They said that they didn't know how to do it, even though they all thought it would be a good idea. Yet,

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when we asked the NYS Department of Health and the CDC how we could get tested, they told us to consult our physician. This is one of the many vicious circles constructed on the data gap four-fold problem.

[9] See New York State Department of Health St. Lawrence Valley Region Fish Advisories https://www.health.ny.gov/environmental/outdoors/fish/health_advisories/regional/ st_lawrence.htm

[10] https://www.albany.edu/sph/faculty/david-o-carpenter. See also Carpenter 'Exposure to and health effects of volatile PCBs' (2015)

[11] Some of the questions up for discussion: Are people aware of the root causes of their health problems? How can people take a more active role in shaping their own health and their environment? What can we do to hold corporations accountable? How can we make it clearer to the people of Massena that they should take on corporations and elected public officials to hold them accountable?

[12] Analysing urine, blood, and breastmilk, twenty-first-century global bio-monitoring studies have concluded that all people alive today contain PCBs within them (Stockholm Convention on Persistent Organic Pollutants 2009).

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Touch, Telepathy, and Tango

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Stuart Nolan, PhD candidate LICA Lancaster University, UK

Touch, Telepathy, and Tango

> In the midst of on-going hype about the power and potency of the new brain sciences, scholars within 'Critical Neuroscience' have called for a more nuanced and sceptical neuroscientific knowledge-practice. Drawing especially on the Frankfurt School, they urge neuroscientists towards a more critical approach – one that re-inscribes the objects and practices of neuroscientific knowledge within webs of social, cultural, historical and political-economic contingency. (Fitzgerald et al. 2014).

The webs that Des Fitzgerald et al mention must include the arts, and the arts need to respond critically to developments in neuroscience. David Gruber has called persuasively for a Critical NeuroArt for a Critical Neuroscience (Gruber 2020). While Gruber's examples focus on finished art objects, this paper seeks to support his call by considering the role that art research and performance art practice can play in bringing a fundamentally embodied approach to the critique of neurocentrism that informs much Critical Neuroscience.

My research into mind-reading began with my performance art practice in mentalism, a theatrical art form that took shape in the late nineteenth century and which is concerned with the potential of the human mind. A mentalist is someone who takes to a platform and performs the possibility that the mind has, or can have, extraordinary abilities.

Performance can be understood as 'doing its own kind of philosophical work, without it being illustrative of concepts or arguments already outlined by "traditional" philosophy' (Cull and Lagaay 2014). Much of my work aims to reveal how, throughout its history, mentalism has staged a performance philosophy engaged and entangled with theories of mind-reading, telepathy, human potential, the cerebral self, neuromysticism and cognitive science. Mentalism is an example of performance as manual philosophy (Johnston 2017) and its images, narratives, gestures, participation, and interaction have particular relevance for philosophies of embodiment, communication, and philosophy of mind. Mentalism is performance as philosophy of mind.

Modern neurocultures have their origins in a number of ideas about the brain that developed in the nineteenth century. Mesmerism provided the idea that the brain can be influenced by outside forces and these forces became conceptualised in relation to the science of magnetism, electricity, vital fluid, and x-rays as well as concerns about social forces such as the persuasive power of

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advertising and propaganda. In addition to this conception of a porous brain, phrenology introduced the notion that the brain is composed of different organs responsible for different functions and psychological capacities. A porous differentiated brain is one that can be cured, improved, and trained in a variety of ways. If you want to cure your sadness, then train the happiness organ of your brain and you will become happy. If you want an extraordinary brain, they you simply have to train it in the correct way.

At the centre of these notions of brain-training and mind-cure was New Thought, a highly influential spiritual movement which coalesced in the United States in the early nineteenth century. The legacy of New Thought today can be found in the prosperity gospel, positive psychology, New Age cultures, and the beliefs of Donald Trump (Haller 2012; Evans 2017).There was much interaction between performers and the proponents of New Thought. The Chautauqua, an education movement in United States in the late nineteenth and early twentieth century, provided a travelling show in which actors, mentalists, magicians, New Thought orators, scientists, charlatans, preachers, and other specialists of the day would share a stage. Early Mentalism developed as performers sought ways to exploit, dramatise, disseminate, attack, and explore New Thought ideas, to the extent that it it can be seen as a Performance Philosophy of New Thought. As such, mentalism is a useful performance art through which to view modern neurocentrism.

Mentalism continues today through the work of theatrical performers, such as Derren Brown, who invite audiences to think of extraordinary mental abilities as inherent and trainable. There is also a new form of mentalism that proposes that extraordinary mental abilities will come from the use of new neurotechnologies. The TED talk and tech conference circuits can be seen as the modern Chautauqua providing a platform for what Regalado, in reference to Elon Musk's Neuralink demonstrations, has called 'Neuroscience Theatre' (Regalado 2020).

Muscle Reading

During the *One Thousand Mindreaders* (2017) project, I trained one thousand people in muscle reading, a nineteenth century mentalism performance technique that enables the practitioner to determine what action someone is imagining by feeling the micro-muscle movements in that person's arm caused by ideomotor responses to their kinaesthetic imagination. A skilled performer can detect these muscle movements by holding the hand of somebody who is thinking about, for instance, where an object is hidden in a theatre, and so find that object in a dramatic manner.

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Artists, designers, technologists, and scientists participated in 38 workshops, performances, and exhibitions throughout Europe and the US at 31 venues including GoogleX, the NHS, and Digital Science. Several exercises were used to train participants to the point where they could duplicate drawings their partner was merely thinking of and to find objects hidden in a room. When they learn these arts, participants are astounded that such capabilities are not more widely known, and they quickly relate them to their particular creative practices. Workshops end with participants considering the question of ownership of the collaborative drawings and deciding who will keep each drawing. The workshops are followed by an unstructured group discussion about how the skills participants have learned relate to their practice, and any issues raised by the experience that the group would like to discuss.

Each workshop takes one hour and has several distinct stages. For participants to learn muscle reading they must first understand that their imaginations can have a physical effect on their bodies that may be subliminal to themselves yet detectable by others. The first step is for them to experience a physical effect of their imagination that can be both felt and seen. For this, I used an effect that was demonstrated by researchers at Aberdeen University using motion-tracking (Lynden K. Miles 2009). The following is the script I use (you are welcome to try this experiment yourself to explore the same experience as the participants):

> I want you to stand-up. Make sure that you're not propping yourself up on anything, that you are standing freely. Good. Now close your eyes. Take a moment to focus on your feet. Notice that they are actively involved in maintaining your upright position. Notice how you tilt a little bit to one side, or backward or forward, and your feet adjust to keep you stable. Standing up is an active process. Standing up is a process of constantly not falling over.
>
> Now, I'm going to ask you to think of something and I want you to genuinely imagine it as best as you can. This works best if you genuinely engage your full imagination. Think of an event that is going to happen in your life in the future. Something you are looking forward to will work well. And imagine yourself physically at that event. Transport yourself. Imagine being there in that moment. Now notice how your body wants to tilt forwards.
>
> Now think of something in the past. Something that genuinely happened in your life. Imagine yourself physically in the past. Notice how your body wants to tilt backward.

Researchers at Aberdeen University studied this effect using motion-sensors. Even when people think that they're not tilting the sensors show that they are tilting a little. The effects can be too

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small for us to consciously feel but whenever we imagine something our brain generates a signal, these signals are being used in various ways to create the next generation of mind-reading devices.

The following activity involves duplicating unseen drawings and is introduced as a game based on nineteenth century parlour games and rational recreations. The game is played in pairs.
One person from each pair is asked to leave the room, they will be the Receiver. While they are away, their partner (the Sender) makes a simple drawing on a piece of paper then hides this Target Drawing. The Receiver comes back into the room and holds a pencil on a fresh piece of paper. The Sender holds their wrist and visualises their Target Drawing, thinking about which way the pencil should move to recreate it. The Receiver gently moves the pencil around trying to sense which way the Sender wants them to go, they will find less resistance in that direction.

Fig.1. *One Thousand Mindreaders* (2018). Stuart Nolan. Participants duplicating drawings through touch. Credit Stuart Nolan.

When they feel they have completed a drawing they compare it to the Target Drawing, looking for any correspondences between the two.

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Fig.2. *One Thousand Mindreaders* (2018). Stuart Nolan. Original drawing (left) with duplication (right). Credit Stuart Nolan.

What the Receiver is sensing in the Sender is something we now call the ideomotor response. When we think of an action, a signal is sent to the hand and that signal causes a tiny muscle movement. Why does this happen? Common Coding Theory is a contemporary Cognitive Psychology Theory describing how our perceptual representations of things we can see, and our representations of physical movements are linked. The theory claims that there is a shared representation, a common code, for both perception and action. Performing an action activates the associated perceptual event and, more importantly for what we are doing, seeing an event or imagining an event activates the action associated with that event (W.E. Prinz and Sanders 1984; W. Prinz 1997). Common Coding Theory suggests that the same neurological and motor processes will deal with doing something, thinking about doing that thing, and watching someone else do that thing. You will get the same physical response in each of these instances but at different intensities.

An interesting advancement in terms of the participant's embodied learning occurs during this activity. When they are told what they are going to do, they express doubt and disbelief that they will be able to duplicate the Target Drawings, but they are willing to try because it is framed as a

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game where any correspondence between the drawings is considered a success. When they compare their drawings, they are visibly astounded at how accurate they have been and vocally exhilarated that they have learned a skill that they had no idea the human body is even capable of. They are surprised that such a capability isn't more widely known, and they quickly relate it to their creative practices or pastimes that involve sensing the physical world in real-time: playing musical instruments, sports, acting, improvising, riding horses, sailing, playing video games, and especially dancing. It is because of this link to dance that the transition to the next activity works well.

Having explored the ideomotor response and played a mind-reading drawing game, participants are now ready to learn the stage technique that made nineteenth century muscle readers both famous and controversial. Participants are first introduced to the following history:

> Muscle reading has gone by several other names. Contact Mindreading. Psychophysiological Thought Reading. Cumberlandism, after the English performer Stuart Cumberland (1857–1922) an opponent of spiritualism who argued that telepathy was impossible and promoted a scientific view of muscle reading (Bown, Burdett, and Thurschwell 2004, 87-108). Hellstromism, after the German performer Axel Hellstrom (1893 – 1933) who performed at a time when German law required all mentalism performances to have a plausible explanation, effectively making muscle reading the only legitimate mind-reading technique (Mann 1985).
>
> A popular use of muscle reading in a stage performance was for the performer to find an object that had been hidden in the theatre by holding the wrist of an audience member who had hidden it and asking them to merely think of the location of the object. This has been the basis of the successful careers of mentalists from J. Randall Brown to the present day. You will notice that this is very similar to the technique we used earlier for duplicating drawings but finding an object in a room is easier because the movements involve the whole body and so can be made larger and felt more easily.

One person, the Hider, hides an object then holds the wrist of their partner and thinks about the location of the object. Their partner, the Seeker, moves around the room and senses the amount of resistance in the Hider's body. Again, the ideomotor response of the Hider will be detectable and the path of least resistance will lead the Seeker to the hidden object. Watching a group of people perform this exercise is like watching an exceedingly slow and stately dance. Participants are intensely focussed on listening and speaking with their whole bodies. They describe the experience as somehow both relaxing and tense at the same time. They begin quietly as they slowly seek, then become increasingly noisy with shouts of excitement as the hidden objects are found.

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This exercise can also be performed outdoors. Several mentalists have performed muscle reading while driving, finding objects hidden anywhere in a whole city.

Fig.3. *One Thousand Mindreaders* (2018). Stuart Nolan. Participants finding hidden objects through touch. Credit Stuart Nolan.

Joseph Roach speaks of activating the kinaesthetic imagination through kinaesthetic emulation in order to engage with history, in his case through the recreation of 50s and 60 African American-generated dance forms (Timothy and Joseph 2009). Similarly, our understanding of the practices of early mentalism and its links with science can be enriched through emulation and revision of its kinaesthetic forms. The muscle reading workshops inspired a more embodied understanding of nineteenth century scientific imaginaries. As one participant said, 'When we think of Victorians talking about "feeling the vibrations" we tend to assume that they are referring to spiritual vibrations but maybe, sometimes, they were simply referring to muscle movements in a scientific manner.'

In addition to challenging assumptions about the history of science, many visual artists found that the practice and science of muscle reading illuminated their drawing practice. Maclagan writes of the 'performance' aspect of automatic drawing that, even when practiced alone, 'there is often a keen

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sense of addressing an invisible, interiorised audience', and that this creates an internal 'drama' (Maclagan 2013). When two people engage in drawing through muscle reading this drama is both internal and external. There is a strong sense of immersive embodiment, of being inside the other. This can create a sense of a double transgression, both physical and mental. Many participants described it as both pleasurable and scary, a form of the telepathic sublime. This telepathic sublime has been recognised as a phenomenon in media reports of mindreading neurotechnologies (Pedersen 2017).

For many participants, the workshops made visible the unexpected resonances between mentalism and dance, especially with somatic practices such as Ohad Narahin's *Gaga* that works as a 'point of access for reflecting on the cognitive aspects of dancing, and the interaction of mind and body' (Katan 2016, 18), and with various forms of contact improvisation. These resonances open a space for dance and movement theories to engage with mentalism, particularly around Foster's notion that, 'kinesthetic empathy takes place in moments of perception when the subject which moves and the subject which is moved seem to dance at the same time' (Foster 2011, 28).

Many dancers found muscle reading instantly recognisable as an instinctive part of their practice. A group of tango dancers related it to the way they touch their partner in the small of the back and try to sense where they intend to go before they move. They found that the neurophysiological science of muscle reading gave them a new language with which to communicate and analyse this instinctual and mysterious aspect of their dance.

Mentalism is institutionally excluded from academia, rejected as a practice unworthy of scholarly attention. This is in part because of its morally ambiguous and transgressive nature. For some participants, performances of telepathy have the potential to transgress and subvert prevailing epistemes of belief, scepticism, superstition, and ritual. In *Telepathy*, Derrida offers no judgment on the facticity of telepathy. Instead, he 'grants that issue free play and stages the paradoxes generated by psychoanalytical writings about telepathy that keep the matter of its reality open' (Clarke 2014). In a comparable, playful and transgressive manner, mentalism is performed 'as real', blurring the line between fact and fiction. There is a difference between traditional theatre 'depicting events as though they were happening' and mentalism performance 'depicting events as though they were really happening' (Leddington 2016). By staging the paradoxes and transgressions of communication, distance, boundary, and contact, mentalism aims to create a performative aporia with regard to the facticity of telepathy.

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Mentalism and muscle reading, in particular, are forms of performative transgressive gameplay that can be analysed through both narratology and ludology. Their performance as philosophy can take the form of procedural rhetorics, which work through situating an audience in an activity of rule-based representations and interactions (Bogost 2007).

The rise of neurocentrism and the cerebral subject in the arts (Vidal 2017) has contributed to the anxiety of neuroexistentialism (Caruso 2017). For some, muscle reading challenged a mind-body dualism that cannot account for the quintessentially performative qualities of arts practices and provided support of a more postcognitivist view (Penny 2017). A kinaesthetic emulation of muscle reading practices brings the body to bear on mentalism's performance philosophy of mind and makes visible a neglected practice of the unseen, the speculative, and the imaginary in the historical and contemporary conception of energy and forces as aesthetic interventions.

> When energetic processes in dance and performance art are qualified as the mobilisation, activation, initiation, regulation, guidance and containment of forces, what consequently follows is that not only aesthetic, but also ecological, economic and political relations come up for debate. (Huschka and Gronau, 2019).

This was certainly true of the workshop debates, which addressed economic and political issues of the body, movement, and touch including data privacy, surveillance capitalism, inappropriate touch, and the importance of appropriate touch for empathy, wellbeing, and social cohesion. Muscle reading builds a unique dialogue between bodies that trades in a dialectic of antagonism and intimacy, friction and flow, conflict and cooperation.

Physical interaction between audience and performer is too often seen as a recent development in performative arts. For several participants, it was enlightening to experience a highly interactive and established performance practice. It was noted that both muscle reading and current interaction in performative arts can be seen as responses to new communication technologies. For nineteenth century muscle readers, the telegraph provided a model for telepathic communication. J. Randall Brown, known as 'The Human Telegraph', could muscle read through several feet of copper wire, and once attempted to detect thoughts through a copper telegraph wire running from Philadelphia to New York (Wiley, 2012). Similarly, audience interaction in twenty-first century performative arts reflects a concern with new communication technologies, digital media, and immersive environments (Borowski, Chaberski, and Sugiera 2013).

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The participants' concern with touch, telepathy, and technology inspired discussions that enlisted muscle reading both in kinaesthetic histories and in re-imaginings of the role of the body in technological futurities. For example, to imagine anticipatory ethics of emerging mindreading technologies, particularly of the kind developed by CTRL-Labs, recently acquired by Facebook, which are fundamentally a muscle reading technology (BBC 2019). This raises the question of how NeuroArt can respond to the telepathic technofuturity envisioned by Elon Musk's Neuralink (Musk 2019) or to the mass mind-reading of surveillance capitalism documented by Zuboff (Zuboff 2018).

Brainwear

The *One Thousand Mindreaders* project led to my current PhD research into 'brainwear'. Direct-to-consumer brainwear devices claim to read one's mind and promise to endow the wearer with extraordinary new brain powers: to experience illuminating mental states; to develop more effective psychological performance; to move objects with one's thoughts. This research explores the thesis that brainwear constitutes a new form of performative neuroascetic practice related to theatrical mentalism.

Theatrical mentalism and brainwear both perform and promote neuroascesis, practices and discourses of direct action on the brain to enhance its performance. They demonstrate a belief in brain training for successful performance in business, personal life, thought, and overtly practical matters. They perform promises of extraordinary brain powers, promote altered states such as hypnosis, meditation, and mindfulness, as self-improvement, and stage the performance of mental acts that influence the physical world. Brainwear is being used by individuals to practice meditation and mindfulness through neurofeedback, by schools to track the mental states of their pupils, and by commercial organisations to surveil their workforce. Such uses raise a host of ethical issues relating to human agency, personal autonomy, mental privacy, cognitive capitalism, and social equality.

I am undertaking an autoethnography of an EMOTIV Epoc X EEG Brainwear headset, wearing it every day for a year. The autoethnographical approach borrows from Autobiology, a creative workshop process developed by the theatre company Curious (L.a. Hill and Paris 2014). Autobiology explores the connections between the body and the mind, between biology and biography, by using autobiological material such as X-rays, clinical scans, and medical documents, and scientific tools to make the body more visible – stethoscopes, blood pressure kits, portable ultrasound (L. Hill and Paris 2020). These personal biological materials are used to create autobiographical writing, performance, and installation work. The PhD study extends the autobiology method by using it as a Critical NeuroArt research method to interrogate the performative instrumental intimacy of brainwear technology itself. Scientific autobiology of the daily, year-long use of a brainwear headset will, on completion, generate performative

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responses to the technology and situate it in both the tradition of mentalism and in the history of experiments in visualising thoughts.

From Thoughtography to Blobology

While muscle readings were developing a form of mindreading based on touch, others were attempting to capture thoughts using new visualisation technologies. Turn-of-the-twentieth century thoughtographers, such as Louis Darget and Hippolyte Baraduc, used cameraless photography to attempt to capture thoughts as directly as possible, exposing the photographic plates without cameras, light sources, or visible objects. The patterns they created were the result of poorly mixed developing solution and the heat from the thoughtographer's skin.

Both Darget and Baraduc believed that thoughts emanated from the human body in the form of a luminous vital fluid but that both the fluid and the thoughts could represent themselves on the photographic plate. What is the nature of this vital fluid? Is it generated by thoughts, as a kind of 'human radioactivity' as Darget suggests? (Chéroux 2005, 119) Is it composed of thought itself? Is it a carrier of thoughts in the form of a 'brainwave', a conception of thoughts that became popular with the invention of EEG?

Margareta Ingrid Christian writes of the imponderable media of thoughtography pointing out its resistance to concrete form:

> The patches of hazy substantiality; dissolving veils; nebulous figures; swirling smoke; luminous vapour; vague shapes – these instances of formlessness persist in fluidic photographs and erupt despite Darget's insistent attempts to render the images concrete and representational. (Christian 2018)

It is tempting to see Catherine Malabou's concept of plasticity as a way of considering thoughtography. For Malabou, plasticity not only describes the giving and receiving of form but also the capacity to explode or annihilate form. Her 'destructive plasticity' can involve an eruption of self-mutability, darkly sculpting new forms from the ruins of the old (Malabou 2008). In this view, the autopoiesis of neuroplasticity is a crucial part of the self-forming of plastic humanity. Both thoughtography and contemporary neuroimaging create visions of eruptive plasticity where thoughts appear to participate in the giving, receiving, and destruction of form, and where forms and formlessness erupt and resist each other, carrying energetic meaning. But to use Malabou's plasticity as a lens with which to view such images, one would have to be careful to navigate the seductive power of thought images.

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‘Brain images are the scientific icon of our age, replacing Bohr’s planetary atom as the symbol of science’ (Farah 2009). They carry considerable persuasive power, appealing to our affinity for reductionistic explanations of cognitive phenomena (McCabe and Castel 2008) and have been called a ‘fast-acting solvent of critical faculties’ (Crawford 2008). The haste to definitively link a pattern in a brain image to a specific thought, ability, or experience has been criticised for resulting in ‘blobology’ (Poldrack 2012), a modern equivalent of the seductive plastic forms of thoughtography.

The blobology debate is generally concerned with the statistical choices made by the labs that generate the images. However, when brain imaging becomes consumer Brainwear, other factors can play a part.

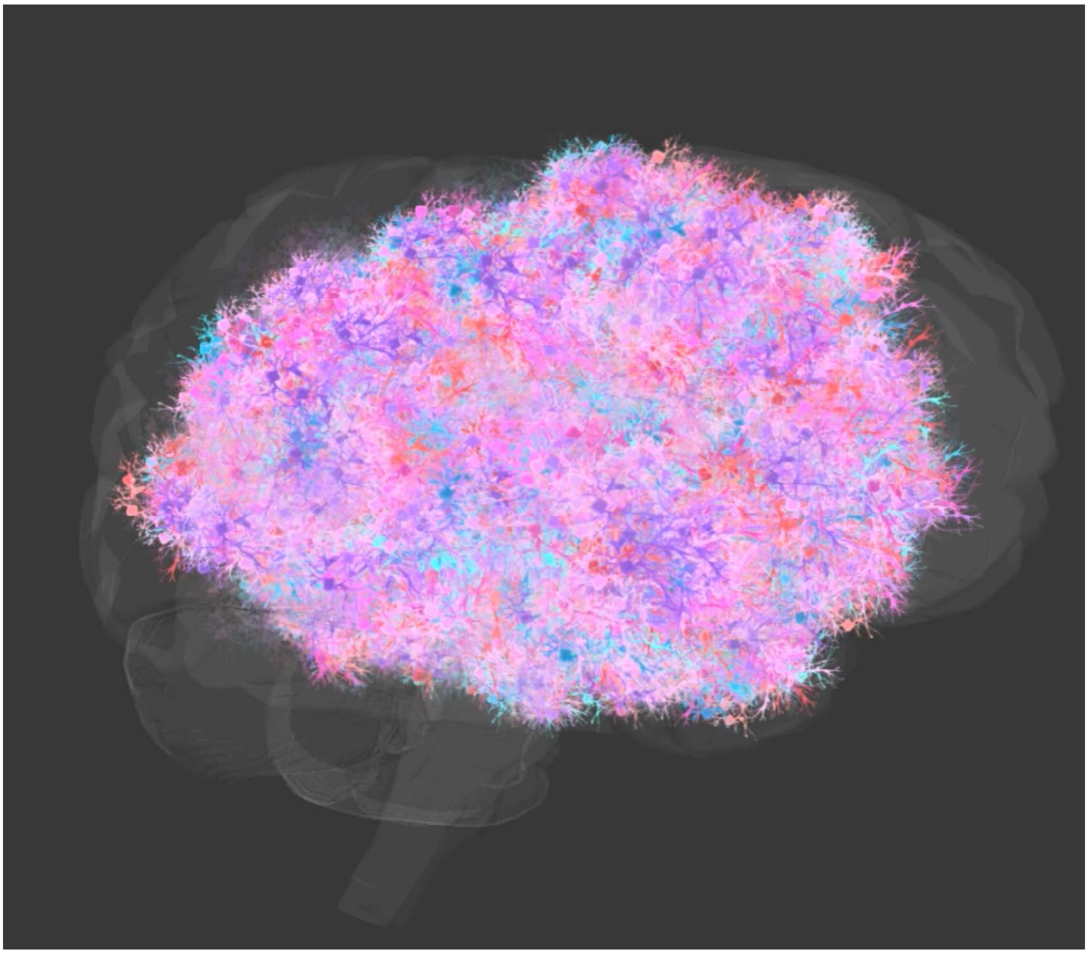

Fig.4. *Unsettled Neuroimage* (2020). Stuart Nolan. Image of the author’s brain using Emotiv EPOC X and BrainViz. Credit Stuart Nolan

The image of my brain in Fig.4 was produced using the Emotiv EPOC X headset and Emotiv’s BrainViz software, sold as a ‘real-time 3D brain visualisation software for neuroscience education and

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exhibitions'. BrainViz uses a static 3D model designed to look like neuronal structures but does not show my actual brain structures, which are much smaller. This design produces a fauxthenticity, intended to be educational but easily misleading for anyone lacking knowledge of brain anatomy. The seductive and misleading nature of neuroimages relates to the lure of what Duchamp called 'retinal art', uncritical art made for the eye and not the mind.

Ironically, science, which hopes to be founded on rationality, inspires a great deal of retinal art.

Conclusion

Gruber suggests that 'the role of art in Critical Neuroscience remains as yet unaddressed and unclear … How exactly Critical NeuroArt manifests, of course, remains open and variable'.

This paper has explored some manifestations and has focussed on research activity rather than the art object. Through an experiential exploration of the phenomenology of muscle reading, *One Thousand Mindreaders* offered a physical confrontation with the histories of mind-reading performances. The experience uncovered previously unsuspected links between dance and mentalism, encountered the playful, transgressive, and sublime aspects of touch and telepathy, and engaged with mentalism performance as philosophy. The workshops initiated discussions about the engagement of art with neuroscience and developed notions of neurotechnological futurity, the telepathic sublime, the cerebral subject, surveillance capitalism, and postcognition. The autobiology of brainwear use further explores these concerns through an extended immersive critique of a neuroascetic device and makes visible its shared history with theatrical mentalism.

These art research projects suggest a number of strategies for Critical NeuroArt. Firstly, that using performance techniques that are fundamentally embodied provides a way of directly confronting neurocentricity. Secondly, working with art forms that have a traditional concern with philosophy of mind opens up a rich variety of robust techniques that have been previously under-researched. Finally, that an engagement with the cultural movements that formed modern neurocultures provides a way of developing an informed and varied Critical NeuroArt.

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The Final Frontier of Fashion: Interdisciplinary approaches to design for microgravity

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The Final Frontier of Fashion: Interdisciplinary approaches to design for microgravity

Introduction

In 2006, Japanese designer Eri Matsui produced a 'zero-gravity wedding dress' (Overbye 2006). The dress was structured around the foundation of a form-sitting pantsuit, decorated with waterfall ruffles that give the appearance of a floor-length skirt, which, when worn in microgravity, 'float like a sea anemone in the ocean' (Finnegan 2014). The dress has been referred to as 'high-tech' (*Toyko Weekender* 2011), illustrating both a misunderstanding about the nature of Matsui's project, and an assumption about clothing design for the new space age. The dress does not employ any Space Age technology, but rather, it employs a novel approach to cut and drape informed by the physics of microgravity. By designing in this way, Matsui demonstrates that fashion design for the new space age does not require wearable technology, nor collaboration with engineers and technologists, but instead it needs an understanding of physics.

Previous research into clothing for spaceflight has been characterised by a focus on wearable technology, and typically involves collaborations with engineers and technologists. While spacesuits must necessarily employ advanced technology in order to protect the wearer from the extreme conditions of open space in the extra-vehicular environment, the same is not true of clothing worn on board a spacecraft or space station. Far less attention has been paid to the environment on board the cabin of a spacecraft (the intra-vehicular environment), where the controlled atmosphere allows the wearing of commercially-available, off-the-shelf 'Earthwear' (Orndoff 2015, 9; Brownie 2019, 88). The intra-vehicular environment is not substantially different to that on-board an aircraft, with the significant exception of the gravitational conditions. Weightlessness is the feature that most visibly and physically differentiates the intra-vehicular environment from atmosphere-controlled environments on the Earth's surface. Even for atmosphere-controlled environments on the Earth, existing clothing research tends to concentrate on wearable technology (Simon at al. 2014), including textile technologies (Schneiderman and Griffith Winton 2016). Typically research is the product of collaborations with engineers and technologists with a remit to develop small wearable devices for biomedical monitoring or augmented reality (Simon et al. 2014, 5). Where there is a brief to design a complete garment or clothing solution, the result is frequently a variation on a form-fitting flight suit, and innovation is not in the form of the garment but instead in the use of advanced textiles or intelligent textiles. NASA has commissioned numerous collaborations to explore a 'direct integration of electronics into clothing', the potential of 3D printed fabrics, in addition to other types of collaboration between

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engineers and textile designers in their Wearable Technology Cluster (Simon et al. 2014, 5). Similar developments are seen in the commercial sector, as in, for example, the development of 'intelliknit' by clothing brand Under Armour for use in form-fitting flight suits for Virgin Galactic (Under Armour 2019).

Despite the 15 years that have passed since Matsui's creation of the zero-gravity wedding dress, fashion designers have not yet revisited the creative possibilities of weightlessness, favouring instead a focus on wearable technology, steered by the spaceflight industry's prioritisation of collaboration between design and engineering or technology. As a result, there are missed opportunities for the fashion industry to creatively engage with weightlessness, and for the spaceflight industry to develop flight suits that visibly engage with the effects of weightlessness in a way that may appeal to the next generation of space tourists. I have previously argued that there is a need to identify a new field of fashion, namely spacewear, which is concerned with the particularities encountered during space travel (Brownie 2019). This new field of fashion is currently shaped, to an overwhelming extent, by the concerns of a spaceflight industry that assumes their commercial passengers will share the view of Virgin Galactic pilot David Mackay, that 'people [will] want to look like an astronaut when they go into space' (Klotz 2012). Thus, the goal of spacewear design to date has been to develop flight suits that aspire toward the aesthetic and functionality of the space suit, despite there being no requirement for this type of functionality when contained within the safe, intra-vehicular environment. I argue that the field of spacewear has therefore neglected to exploit the potential opportunities that arise through creative engagement with weightlessness, and that, in order to achieve this goal, fashion design must to collaborate with the field of physics, and informed by those with experience of microgravity.

Creative practice in the post-gravity environment

Fashion design is a practice informed or constrained by gravity in various ways. At the core of fashion design and dressmaking are drape, weight, and silhouette: drape is understood as the extent to which a fabric resists gravity (Cusick 1965; Cadigan 2014, 140); the weight of a fabric is, on Earth, a product of its thickness and density; silhouette is understood as the flattened outline of the erect body (Jenkyn Jones 2011, 156). Therefore, as I have argued (Brownie 2019), the weightless environment poses challenges to methods and processes that have long been taken for granted in fashion design and dressmaking on Earth, and those methods need to be reconsidered in light of the emergence of a commercial space travel industry.

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In the few examples of wearable technology that have been developed to respond to the effects of weightlessness, the aim has been to minimise or eliminate its effects. NASA's V2 Variable Vector Countermeasure Suit, developed by biomedical research organisation, Draper Laboratory for NASA in 2011, employs flywheels to create artificial resistance and replicate the sensation of gravity. The suit restores the sense of orientation lost in microgravity by generating resistance when movement is made parallel to a downward direction, and little or no resistance when movement is perpendicular to that direction (Duda, 2014, 3). More recently, Valentina Sumini et al (2020, 3) developed SpaceHuman, a soft robotics prosthetic that aims to help the human body adapt to weightlessness. The team describes the wearable device as 'restoring the right motion and balance of our body' thereby assuming that there is a 'right' or correct orientation. While such projects are useful in helping to acclimatise the human body to the microgravity environment, where acclimatisation is the goal, there is surely also potential to embrace the effects of microgravity, and to creatively engage with weightlessness.

A number of creative practitioners have explored the exciting possibilities of weightlessness. In 1993, author and artist Arthur Woods produced a small, angular sculpture, *Cosmic Dancer*, which was exhibited in space on board the Russian Mir space station. The sculpture was a smaller and more lightweight model of one from a series of 3-metre tall acrylic and steel sculpture (the series was made between 1981 and 1993). Each in the series was oriented at a different angle, as though without a common orientation or 'resting point' (Woods 1993, 299). The proposal for a small *Cosmic Dancer* intended for a weightless environment was a natural progression from these Earth-bound predecessors. In the microgravity environment, the artwork would have no definitive orientation. This 'physical empirical' approach to making art for space can be distinguished against a more illustrative, representational 'space art' (Pocock 2012, 336); in the words of renowned sci-art artist Eduardo Kac (2005, 22), it might be described as 'art that engages with outer space materially'.

Further creative engagements with microgravity took place as a result of opportunities presented by the curatorial commissioning arts organisation, Arts Catalyst, for the Microgravity Interdisciplinary Research (MIR) initiative (2000 - 2004). The MIR initiative invited practitioners and researchers across a variety of arts and science disciplines to experience microgravity on board reduced gravity aircraft. The primary aim was to make the environment of microgravity accessible to those considering its aesthetic possibilities and to 'promote cultural engagement with space' (Triscott et al. 2014, 10; Triscott 2005, 6). Participants included dancer Morag Whigtman, whose aim was to explore 'suspension in an environment where fear of falling is not an issue' (*Falling Without Fear*, 2001), artists Ansuman Biwas and Jem Finer, whose installation featured three cubes containing liquids and small spheres which explored

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the behaviour of liquids in microgravity (*Wave/Particle*, 2001), and Mike Phillips/i-DAT, who used the reduced gravity flight to test a prototype for a monument designed to operate in microgravity consisting of six loosely tethered cubes designed to drift while partially constrained by loose tethers that connect the cubes to one another (*Constellation Columbia*, 2003) (Triscott and La Frenais 2005, 62; 54; 84). The Arts Catalyst projects illustrate that material engagement with weightlessness does not require the use of what might be considered 'space-age technologies'. Rather, it can be concerned with what might be considered low-tech materials and subjects, such as the human body and its movement, and how these are defamiliarised by weightlessness.

Following the Art Catalyst's MIR initiative, there were few other creative engagements with weightlessness until the launch of the MIT Media Lab's Space Exploration Initiative (2017- present). The Space Exploration Initiative aims to bring together artists and designers with engineers and scientists within a speculative design remit and 'deploy bold visions that venture beyond the rational constraints of most academic grants' (Ekblaw, n.d.). The initiative has yielded a number of projects that explicitly respond to microgravity conditions, including the aforementioned SpaceHuman (Sumini et al). Another is Nicole L'Huillier, *Sands Fish*, and Thomas Sanchez Lengeling's *Telemetron Orchestra*, 'a collection of novel musical instruments designed explicitly to be performed in microgravity' (MIT Media Lab 2019), and Andrea Lauer and Xin Liu's *Orbit Weaver*, a wearable device that casts out web-like strings that act as tethers to anchor the weightless body to surrounding surfaces (MIT Media Lab 2017) .
The lack of activity in the sci-art field from 2004 to 2017, that is in the years between the Arts Catalyst and MIT initiatives, indicates that creative approaches to microgravity can only take place when an interdisciplinary environment with an explicit remit to consider microgravity is created.

New interdisciplinary concerns

Previous creative engagements with microgravity reveal the range of concerns and reactions to the experience of weightlessness that may come to define an emerging field of creative practice. This new field must first recognise the extent to which gravity has defined creative practice throughout its history on Earth, and that microgravity requires a fundamentally different approach to practice. Theorists and practitioners who have considered creative practice for the weightless environment acknowledge the extent to which existing approaches must be revisited and revised. Maja Murnik (2016, 68), reflecting on the similarities between the virtual and microgravity environments, suggests that 'art beyond gravity derives from entirely different foundations' to Earth-bound art practice. Similarly, Kac (2005, 18) argues that we must recognise the extent to which 'gravity plays a fundamental role in the forms and events that we are able to create on Earth and that forms and events [for weightlessness] might be radically different'. An appreciation of the effects of weightlessness prompts what can be described as *post-*

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gravity experience, which in turn has the potential to create a paradigm shift in creative practices.

Descriptions of the experience of weightlessness help to quantify the radical difference in approaches to practice in normogravity and microgravity. Arthur Woods (1993, 299) observes that, 'consciously or unconsciously, artists conceive and [create] with gravity determining the eventual resting point of the work... Our response to its aesthetic "rightness" is based on our own experiences within the terrestrial environment'. By contrast, in the weightless environment, there is a profound sense of ungroundedness. Reflecting on images captured in space, Benjamin Lazier (2011, 610) remarks that they 'confound one of the presuppositions of phenomenological analysis, that the body has a customary orientation in space: up and down, front and back, above and below, before and behind.' It is this ungroundedness, through its association with weightlessness, which has been the focus of recent creative engagements with space (Eshun 2005, 28). The sense of unsteadiness and the loss of an 'upright' orientation separates the common experience of being grounded on Earth's surface from the apparently liberating experience of space travel freeing the human body from the sensation of being Earthbound.

Inevitably the lack of orientation affects the experience of the human body in space, as well as the body's interaction with, or viewing of, designed objects. Following her experiences of reduced-gravity performance for *Fluid Trajectory* (2001) and *Analogies* (2004), choreographer and dancer Kitsou Dubois describes how weightless performers must 'create subjective egocentric references' (Veillat 2004). Without a common understanding of up or down, performers 'build their own structures on [a] subjective axis' (Dubois 2001). Annick Bureaud (2006) describes a loss of awareness of where the body ends and where its surroundings begin. Without the sensation of pressure on the epidermis, skin 'stop[s] playing the role of sensor between the "interior" and the "exterior", between "me" and "what is not me".' If the external limits of the body are unclear, then so too is the division between body and clothes. Though neither Dubois nor Bureaud explicitly discuss clothes, their observations about the body in microgravity provide a foundation for thinking about the clothed body, and the body's relationship with clothes that do not rest on the body as they do in normogravity, but instead float around it. One of the most notable characteristics of descriptions of a post-gravity experience, and of many of the examples of practice referenced above, is that they do not explicitly feature - or seek to advance - technology. Implicit is an understanding that, aside from the spacecraft or aircraft that grant access to microgravity conditions, engagements with weightlessness need not be *high-tech*. Creative practice throughout history has employed technology to lesser or greater degree, and our experience of normogravity on Earth is typically not technologically mediated. Similarly, awareness of different gravitational conditions can inform creative practice and technology need play no part.

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Material engagement with weightlessness does not require the use of what might be considered Space Age technologies. Rather, it requires an understanding of the effects of weightlessness on material objects. In the field of fashion design, designs tend to erase the effects of weightlessness. Form-fitting flight suits modelled on those of the Jet Age, fit close to the skin so they limit the potential effects of weightlessness on the garment, or on the relationship between the garment and the wearer's body. Such suits are the product of a focus on technology, and the result of collaborations between fashion designers and engineers. By virtue of the focus on technology, and involvement of specialists in technology, there are missed opportunities to exploit the effects of weightlessness. The field I have previously identified as 'spacewear' (Brownie 2019) does not need to concern itself, by default, with wearable technology. In order to exploit the creative potential of microgravity, the field needs to move away from collaborations with engineers and technologies, towards collaborations with disciplines that have an understanding of weightlessness and its effects, that is, with the field of physics.

Writing on interdisciplinary collaborations between art and physics, Nicola Triscott (2018, 14) suggests that 'astrophysics and particle physics probe the limits of the known… and present a kind of abstraction or transcendence that can free us from commonsensical thinking'. Triscott (2005, 6) has herself experienced weightlessness, and consequently come to appreciate that 'to defy gravity is to defy the accepted, the unquestioned, and the status quo'. Challenge to 'commonsensical thinking' and the 'status quo' of normogravity is required for a new field of post-gravity design. Triscott's observations allude to the possibility of a post-gravity methodology, in which critical reflection on the extent to which gravity has been taken for granted in past practice forms the foundation for a practice that engages with weightlessness. With the goal of establishing a new field of post-gravity fashion practice, spacewear becomes a collaboration between fashion design and physics. The aim of creative research in spacewear would be to identify the extent to which existing fashion practice is informed by gravity, and then to understand the extent to which that practice can, or must be, revised to account for the effects of microgravity.

A revised approach to fashion/science collaboration

Fashion-science collaborations are not new. Typically, these take place within art-science initiatives that pair one narrow discipline with one broader field, either by bringing together practitioners from a broad range of creative disciplines with one narrow scientific field, or vice versa, bringing together researchers from a variety of scientific disciplines with practitioners from a single creative discipline, such as fashion. In the field of physics, a notable initiative that breaks the mould is the arts residency programmes, Arts at CERN, which hosts practitioners from a range of creative disciplines, including fashion designer Iris van Herpen (Koen 2017, 2). Other initiatives that have brought together fashion designers with

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researchers across a range of scientific fields include MIT's Descience and a more recent project at the University of British Columbia. Both paired fashion designers with scientific researchers (Amsen 2020, 6959-60). A common goal of these projects was to provide researchers in the sciences with methods of communicating their findings to a new, broader audience (Lacey 2014; Amsen, 2020). These are presented as outreach projects, with the goal 'to make science tangible and accessible to everyone' (Desciences' Executive Director, Yuly Fuentes-Medel, cited in Fenton 2014), beginning with an assumption that the creative languages of art and design are accessible to the general public. These projects employ fashion primarily as a mode of communication, and one that is assumed to be more accessible to a broad audience than the sciences.

A visual language of pattern and colour is referenced frequently in descriptions of these fashion-science initiatives, with the implication that the role of the designer in these collaborations is primarily to identify visual characteristics of scientific experiments and processes, and then to incorporate these into garments. Iris van Herpen's *Magnetic Motion* collection (spring 2015), the outcome of her work at CERN, took inspiration from the 'shapes and patterns formed by particles responding to magnets' (Koen 2017, 8). Epigenetics researcher at British Columbia, Samantha Schaffner, described designers 'finding visual patterns in...plates of yeast' (Amsen 2020, 6960). In the garments produced under the Descience initiative, '[r]ed blood cells become draped ruby fabric, neuron scans transform into holographic brocade, and corsets represent bone graph scaffolding' (Fenton, 2014). The practical outcomes range from garments that are broadly inspired by the visual characteristics of a lab experiment to those that more explicitly illustrate a scientific process.

The consequence of an approach that pairs designers with scientists to interpret and communicate their ideas in an accessible visual language, is that the resulting garments do little more than illustrate scientific concepts and practices. Patterns from science are employed as adornment. The pairing of one scientist with one designer typically results in a series of individual garments, each a novelty judged by its own standards. With too few stakeholders, Kaner and Coskun (2017) argue that such collaborations can only result in findings with application limited to one project or one context. While effective at achieving the stated goals of increasing the public visibility of scientific research, this approach to collaboration between fashion and science is less effective when there is a need to establish a new field of fashion practice. For spacewear to emerge as a new discipline of fashion, there is a need to identify concerns across a broad range of contexts. This requires a new approach to art-physics collaboration, moving beyond the superficially visual and involving greater knowledge exchange as well as a greater number of participants.

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One of the challenges to overcome in arts-physics knowledge-exchange activities is that the fields of design and physics require vastly different technical expertise and operate with very different languages (Koek 2017, 3). Fiona Crisp and Nicola Triscott (2017, 11) observe that physics 'operate[s] at scales and levels of complexity that lie beyond the imaginative and cognitive grasp of lay publics'. It is therefore helpful to reflect on the nature and extent of the knowledge needed to appreciate the effects of gravitational conditions on clothing and the clothed body. Thus, it is helpful to differentiate between lived experience and formal scientific knowledge. Just as the everyday experience of gravity informs design on Earth without the requirement of an advanced scientific understanding of how gravity functions, so too can the experience of weightlessness be understood. The phenomenology of weightlessness is appreciated without a complete understanding of gravitation science or the mechanics of microgravity. This important distinction between the phenomenology of weightlessness and the physics of microgravity is one way designers and other creative practitioners might be informed by a field otherwise too arcane to be informed by.

Phenomenological understanding of the experience of weightlessness lies not only with physicists but also with those who have first-hand experience of spaceflight, including astronauts, astronaut trainers, and passengers of reduced gravity flights, many of whom are creative practitioners themselves (as in participants of Arts Catalyst and MIT Media Lab projects). With their different expertise and languages of expression, these participants may collectively offer new insights into the effects of weightlessness, some of which may be more accessible to spacewear designers.

Conclusion

Amanda du Preez (2019, 83-85) identifies, in representations of space and the astronaut, 'a post-Earth worldview' embodying 'collective dreams' of 'displacement or departure from Earth', in the context if the inevitability of the colonisation of space and eventual abandonment of an exhausted Earth that has been depleted of its natural resources. In addition, the post-Earth worldview recognises that Earth is not the centre of *the* universe, or even the centre of *our* universe. Similarly, post-gravity thinking recognises that normogravity is in fact not-normal in the universe, but rather, peculiar to Earth. Normogravity has constrained human approaches to design in the past, but may not in a post-Earth future. In order to design for the new space age, it is important to recognise the extent to which existing design practice has been shaped by gravity, and to understand how different gravitational conditions require revision of established design practices. A new field of spacewear can only emerge if fashion designers adopt a post-Earth, post-gravity approach to practice which requires knowledge not native to their discipline.

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The spaceflight industry recognises that the new space age will be shaped by interdisciplinary collaborations and, more so than the previous Space Age, that these collaborations will involve civilian or 'citizen participants' (Barschke et al. 2012; Kaminski 2016). However, where these collaborations have involved fashion designers, they have tended to pair them with engineers and technologists, with a goal to develop wearable technology. The nature of flight suit designs commissioned by commercial spaceflight providers suggests that the spaceflight industry may not yet be ready to fully embrace the potential for a spacewear that creatively exploits weightlessness. If this is the case, it is the responsibility of the fashion industry to make the first move. Fashion needs to identify its own priorities for spacewear design and pioneer new approaches to fashion for microgravity.

However, the fashion industry cannot pioneer alone in this field. There is knowledge located in other sectors that is necessary for the design and production of viable spacewear. Therefore a new approach to collaboration is needed, one which involves a variety of stakeholders and considers the experience of weightlessness as much as, or more so than, the mechanics of gravitation. Collaborations leading to the establishment of a field of spacewear design must involve not only fashion designers and physicists, but also those with first-hand experience of weightlessness. These collaborations must proceed with a goal not to produce a single garment or collection with limited application, but with the aim of identifying a set of considerations that can become the foundations of a widely-applicable, post-gravity approach to fashion practice.

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The Final Frontier of Fashion: Interdisciplinary approaches to design for microgravity

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What the World Needs Now is Artists and Designers Engaged with Science

8 January 2021 online (postponed from June 2020)

Provocation - Call for Papers

Since the 1960s we have seen numerous art-science experiments, often initiated by artists. Inter- and multi-disciplinary collaboration has never been a simple process. Some argue this is due to disciplinary boundaries emphasised in our educational system. For others, the issue is a lack of attention to real differences in thinking and approach. From the point of view of science, art is useful when it illustrates already established scientific theories. For many scientists, art provides a useful gateway to the general public, employing aesthetics to seduce audiences into engaging with scientific ideas. It seems that many scientists labour under the idea that art is simply the equivalent of beauty, despite the fact that for more than 100 years, and at least since Dada, artists have challenged this idea.

Questions this conference asks include:

- What is the best that art-science collaborations can offer?
- What can be achieved by artists working with scientists that cannot be achieved by artists alone, or scientists alone?
- On the one hand, we ask what can scientists learn from artists? On the other, is it the role of art to illustrate important scientific truths, such as, climate science? In other words, what is the point of sci-art collaboration?

Symposium Speakers and Abstracts

Keynote Speaker : Katy Barrett, Curator of Art Collections, Science Museum, London

Has the world always had artists engaging with science?

I will look at the long history of art and science in dialogue, considering the many ways in which artists and scientists have inspired, criticised and informed one another, using the same tools see and asking the same questions. Rooted in the collections and histories of the Science Museum, and asking the same questions. Rooted in the collections and histories of the Science Museum, will consider a series of moments at which art and science interacted to change the course of I both. Painting, sculpture, drawing, photography, and digital media all feature as shared visual approaches that have also had a broader public impact in disseminating changing ideas. We will how a series of disciplinary shifts from the 17th to the 20th century have served to shape how we see art and science as engaged or otherwise. Art has always been at the heart of the Science Museum. I ask what we can continue to learn from collecting and interpreting art in this context.

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Bio: Dr Katy Barrett is Curator of Art Collections at the Science Museum, London. She has held various previous posts in national and university museums, and has higher degrees in History of Art and History of Science. She is co-author of *The Sun: One Thousand Years of Scientific Imagery* (Scala, 2018) and co-curated 'The Art of Innovation: from enlightenment to dark matter at the Science Museum' (2019-20). She is active on social media as @SpoonsonTrays.

Esin Aykanat Avcı & Ilgım Göktürk Basal (Turkey)

A Laboratory or an Art Studio

We, Ilgım Göktürk Basal and Esin Aykanat Avcı, are an artist and a scientist who have been working together on bio-art projects since early 2019. What brought us together was, as an artist who has been reflecting on and working with nature for many years, my coming up with bio-art project ideas containing procedures that require scientific knowledge. Although I applied to articles to solve these procedures, it was impossible for me to learn and understand all the terms and techniques and perform them in my art studio by myself. At this point, I applied to Ilgım, my long time friend and a Research Assistant in the Department of Biochemistry. The technical part of the project was easy for her, but the crucial point was the dialogues developed between us about the context of the art project from two different perspectives. This project has led us both to start seeing the lab as an art studio as both science and art require originality and therefore creative thinking. They both feed each other very efficiently, as they are both about understanding the meaning of life and life on earth.

Our production processes, which are based on our dialogues and reflecting on the essence of the material, have led us to explore the essence of biological beings. This paper includes our working practices, experiences, challenges we have faced, the benefits of our mutual talents and different points of view during the processes, how we transformed the laboratory and the results of the processes based on our first project in 2019, The Essence of Life, Cross Transformation and our ongoing new project based on DNA isolation from living tissues .

Combined Bios: Esin was born in 1986 in Ankara, Turkey. She graduated from Hacettepe University, Department of American Culture and Literature in 2009 and then pursued fine arts at the Graduate Program of Hacettepe University Faculty of Fine Arts, Department of Ceramics. She conducted her Master's thesis research in Cardiff School of Art and Design in Cardiff, U.K. in 2012-3. In 2017-8, on a Fulbright Visiting Student Researcher Scholarship, she conducted her dissertation research in Newark, Delaware, USA. Esin continues to exhibit her work on human-nature interaction and the possibility of being physically one with nature, with a focus on process in the forms of installation, sculpture, video, land art and bio-art, some of which have been included in national art collections. She is currently working on her Ph.D. dissertation at Hacettepe University

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and works at her studio at the Artist Residency Program in Cer Modern, Ankara.

Ilgım Göktürk Basal was born in 1986 in Ankara, Turkey. She received her Master's degree in 2011 and Ph.D. in 2016 from Hacettepe University Nanotechnology and Nano Medicine Dept. In 2015, she was a guest researcher at Linköping University, Sweden, in the Dept. of Physics, Chemistry and Biology. She has many publications in national and international refereed journals on subjects such as affinity-based nanomaterials and biosensors. She still continues her academic studies as a research assistant in Hacettepe University Department of Chemistry, Biochemistry.

Barbara Brownie (University of Hertfordshire, UK)

The Final Frontier of Fashion

Interdisciplinary projects for the commercial space age are dominated by collaborations involving engineers and biologists. Where designers collaborate with scientists in production of work for space travel, their goal is often to advance digital or mechanical technology. While there has been substantial research into wearable technology and textile technology for space travel, the field of fashion has not yet explored opportunities to collaborate with, or to take inspiration from, the field of physics. Microgravity is one of the most dramatically unfamiliar features of the spaceflight environment, and weightlessness is identified by potential space tourists that one of the most appealing factors influencing their desire to engage in commercial space travel. There is scope, therefore, to consider how designed objects, including clothes, behave in microgravity. This research must be distinguished from existing investigations into wearable technology, in part to recognise that not all engagement with space travel must be high-tech. The condition of weightlessness forces fashion designers to revisit many of the assumptions that have long been fundamental to fashion design, in particular those related to the weight and drape of fabric, and the prioritization of the silhouette. Weightlessness causes clothes to be malformed and reoriented in ways that require entirely new approaches to shape and form, and to the relationship between clothes and the body. These new approaches to design make it possible to develop garments that visibly evidence the effects of weightlessness.

Bio: Dr Barbara Brownie is Principal Lecturer in Visual Communication at the University of Hertfordshire, where her research investigates the relationship between clothes and the body. Her recent books have included *Acts of Undressing: Politics, Eroticism, and Discarded Clothing* (Bloomsbury, 2016) and *Spacewear: Weightlessness and the Final Frontier of Fashion* (Bloomsbury, 2019)

Fiona Crisp (Professor of Fine Art, Northumbria University, Newcastle, UK)

The Cultural Negotiation of Radically Remote Science

Historically, the cognitive and imaginative dislocation of lay-publics from the extreme abstraction of fundamental science has been understood as an issue to be addressed via public outreach initiatives; within this paradigm, the science itself is understood as essentially 'complete' and the task of communicators (sometimes with the added cultural advocacy of art) is to make the science more publicly accessible. Recent shifts in critical theory within the realm of New Materialism (Haraway, Barad), as well as questions regarding how empirical data can be reconciled with lived experience (Dowker), break down this rigid dichotomy of nature and culture; within this new paradigm, all fields are relational and contingent - but how do we negotiate this new landscape?

Fundamental is a project that approaches these questions by bringing together a broad constituency of scientists, artists, philosophers, curators and publics. Premised on practice-led research that combines critical rigour with performative methodologies, the project challenges existing, instrumentalised models of collaborative practice between the cultures of arts and science that too often rely on a mutual exchange of services where access and content are traded for impact and outreach. Instead, the research approaches knowledge-making practices as 'social-material enactments that contribute to, and are part of, the phenomena we describe'; in this respect artist, scientist and publics are placed inside of, and indivisible from, the knowledge-making process itself – a fundamental re-positioning with profound implications.

Bio: Fiona Crisp is Professor of Fine Art at Northumbria University, Newcastle, UK where she is a founder member of The Cultural Negotiation of Science, a research group that brings together artists, academics and research students whose practices engage with expert cultures across a broad spectrum of science and technology. Crisp's practice resides at the intersection of photography, sculpture and architecture where the limits and capabilities of both photography and video are explored through the making of large-scale installations. For the past decade she has been working with institutions and individuals involved in fundamental science, most recently via the research project, 'Material Sight'.

Crisp's work is represented by Matt's Gallery London and is held in several national permanent collections in the UK including Tate, the British Council, Arts Council and the Government Art Collection

Jessica Hough (Andrew W. Mellon COSI Curatorial Fellow in Photography at the Art Institute of Chicago, USA)

'A Good Scout' in Art and Life: Generative Systems & Collaborative Techno-Art-Activism

In 1973, School of the Art Institute of Chicago student Marsha Sokol photocopied her nude body in sections, producing a fragmented mirror image of herself, pressed against the picture plane, eyes shut to protect her retina from the copier's light. Sokol was a part of Generative Systems, an academic program at SAIC founded in 1970 by Sonia Sheridan, which introduced students to the artistic potential of emerging technologies such as the photocopier and pre-networked computer. Between 1970 and 1980, Sheridan and Generative Systems students collaborated with scientists and engineers to create works of art that reconfigured artists' relationships to technology. Simultaneously—and paradoxically—they used the machines to produce political posters for Anti-War and Women's Liberation rallies at unprecedented speeds.

From the 1960s to the 1980s, various scientific and consumer goods corporations established artist residency programs across the United States, leading to developments in both art and technology for companies like 3M, IBM, and Bell Labs. Collaboration flourished as a primary creative method, both among artists and between artists and scientists. This paper traces this history, taking on Generative Systems as a case study. I focus on Sheridan and her students' photocopier-based work, viewed through three sites of collaboration: collaboration between individuals, between artists and corporations, and between humans and machines. Considering Generative Systems' photocopier-based work through this set of relational interfaces, I argue first for the machine's centrality as a tool for negotiating and visualizing collaborative entanglements in the 1970s. Second, I suggest that, because of its ties to corporate office space and gendered secretarial work, the photocopier as artistic medium uniquely addressed the gendered body's role as a site for political discourse in the mid-1970s.

Bio: Jessica Hough is a doctoral student at Northwestern University in the Department of Art History and a Mellon Fellow in Gender and Sexuality Studies. Her research focuses on late-20th-century art, with an emphasis on video and 'new' media, performance, activist art, feminist historiography, and queer theoretical approaches to art history. She received a Master's in Film Studies from Columbia University, and a Master's in Art History from the University of Pennsylvania. Currently, she is the Andrew W. Mellon COSI Curatorial Fellow in Photography at the Art Institute of Chicago. Previously, she worked at Electronic Arts Intermix, Artists Space, and the Museum of Contemporary Art, Chicago.

Alana Jelinek (Vice Chancellor's Research Fellow, University of Hertfordshire, UK)

Bio: Alana Jelinek was awarded her PhD from Oxford Brookes University in 2008 in the fields of art history and fine art practice investigating art as a democratic act, the interplay of content and context in contemporary art. From 2009 until 2017, she was with the University of Cambridge in the Museum of Archaeology and Anthropology. The first of her two post-doctoral research positions with the museum was an Arts and Humanities Research Council Fellowship, investigating the relationship between collectors, collections and the collected, where the collected are both people and things. Her second post-doc was as a senior researcher on a European Research Council international and multi-disciplinary research project with Nicholas Thomas as the Principal Investigator, researching

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Oceanic art in European museums. Alana Jelinek came to the University of Hertfordshire for her third post-doctoral research project in Dec 2017. She is the group leader for Theorising Visual Art and Design research group and her most recent monograph is called, *Between Discipline and a Art Place: The Value of Contemporary Art* (Bloomsbury 2020) which argues for a new way of understanding the role and value of art in society.

Sam Jury (Researcher, University of Hertfordshire, UK)

Are You Thinking What I'm Thinking?

Where is the line between compromise and collaboration? When do issues of language and social conventions create environments for 'contagious agreement'? When do the requirements of funders create a tension between fulfilment and integrity. When we collaborate how do we know what we don't know? How can we say we don't know and when do we ask the most obvious questions?

Climart (2012 – 2017) was a highly visible and widely published five-year cross-disciplinary research project that bought together artists, psychologist and natural sciences to collaborate on ways in which visual art could communicate climate change. A key tenet, was that the psychologists would be a kind of 'glue' between the creative arts and the natural scientists, especially when it came to issues of language and communication. That was the proposition, yet the process of testing it proved to throw open a whole new set of observations on, not just how disciplines work together, but also how internal and external forces can come into play and shape the body that is the collaborative team.

Bio: Sam Jury is a visual artist, Senior Lecturer in Fine Art and Research Group Leader of Contemporary Arts Practice at the University of Hertfordshire. Her practice-led research, often collaborative and cross-disciplinary, in artist filmmaking, investigates the psychological impact of moving image and societal narratives of loss and trauma. In 2018 her films screened at the Ann Arbor Film Festival, USA, Whitechapel Art Gallery, UK and of Bienal de la Imagen en Movimiento, Argentina. In the same year she was nominated for the Jarman Award and won the Research in Film (RIFA) Award, presented by the Arts Humanities Research Council. She is currently working on a major film project exploring memories of place and event in the de facto state of Abkhazia in the Southern Caucuses.

Ariane Koek (Initiator and Founding Director of Arts at Cern)

Entangling Matters: How and Why Science and Arts Collaborations Count

From painting, large scale installations and fashion, to architecture, sculpture, film, digital art and photography, physics is one of the key sciences which captivates and continues to inspire the imagination of artists and designers. Fashion designers Hussein Chalayan and Iris van Herpen, architects like Jacques Herzog and Sou Fujimoto, and contemporary artists like Mariele Neudecker and Olafur Eliasson collaborate with physicists regularly.

So what is it particularly about physics which is so attractive to artists and designers? And how and why do the best collaborations between them happen?

Using the example of Arts at CERN, which I initiated in 2009, and then went on to design, develop and direct for 5 years, I will make the case that arts/science collaborations are even more important than ever during and after the Corona Pandemic. I will outline how they will now be increasingly transformative, building on one aspect of their past in the 1960s to create a new future.

Drawing on over 11 years working directly in the arts/science field, I will discuss and show examples of how the arts' and sciences' different modes of seeing, describing and discovering the world around us leads to innovations and new creativity. I will also show how at the centre of both disciplines is the imagination, and how in the 21st century we are finally acknowledging more openly its role to play in the sciences. The imagination is the critical factor in enabling balanced and fruitful collaborations between the disciplines. By sharing examples of everything I am outlining we can discuss and share best practice and models for our collective arts/science future.

Bio: Ariane Koek is an independent international arts/science, transdisciplinary strategic consultant, creative producer, curator and writer in the fields of arts, sciences, technology and artists residency programmes. She is the author of Entangle: Physics and the Artistic Imagination (Hatje Cantz 2019) and is internationally known for initiating in 2009 the arts/physics Arts At CERN – based at the world's largest particle physics public research laboratory outside Geneva, Switzerland. Today as an independent, she is senior arts advisor and associate for the the Museum for the arts and science of perception known as The Exploratorium, San Francisco USA, creative partner of the new Cavendish Arts Science Programme at Cambridge University UK, and the founder and producer/curator of Earth
Arts Science Programme at Cambridge University UK, and the founder and producer/curator of Earth
Water Sky environmental arts and science residency programme at Science Gallery Venice, Italy. She is also co-curator of Backlight – the Finnish Photography Triennale 2020 and Real Feelings: Emotion and Technology which opens at HEK, Basel Autumn 2020 and MU, Eindhoven, Spring 2021. Previous exhibitions in 2019 include -'Entangle: Physics and the Artistic Imagination' Bildmuseet, Sweden and 'Keith Tyson: The Matter of Painting' Claude Monet Museum, Paris, France.

Ulrike Kuchner (Research Fellow, Faculty of Science, University of Nottingham, UK)

The value of ArtScience: what lies at the intersection of art and science?

In a time in which scientific knowledge is in danger of being discredited, we return to revelling in the responsibility of art and science. Each community has their own ways of communicating, ways of expressions, levels of sharing and exchange of material — but despite the disparities of their profiles, artists and scientists have a common ground: the fundamental desire to understand and describe the world around us and therefore to produce knowledge and uncertainty.

As a creative crossroad, the contemporary field of ArtScience as an independent artistic practice has been gaining momentum. The art is based on interdisciplinary collaborations or uses scientific methods and tools or is based on scientific research. Though ArtScience is often used for scientific outreach, its main intention is not to explain the science, nor is it science visualisation. Rather, it allows people to sense the awe and emotions that we feel when we think about outer space, about the tools of technology, about climate change, about exploration and discovery. It investigates, shapes and rejects, merging the objective and the subjective with equal voices.

In my contribution, I will discuss the role of emotions and aesthetics in scientific paradigms, raise questions related to the freedom of art and science in uncertain times, the role of the public in scientific exploration, and how art can add individual value and personal meaning to science. Will art and science converge in their identities, their institutions and evaluations? If so, how can we facilitate spaces of mutual experimentation and share knowledge collectively and accessible to everyone?

Bio: Ulrike Kuchner was born and grew up in Vienna, Austria. After school, she (simultaneously) studied astrophysics at the University of Vienna, as well as fine arts (paintings) at the University of Applied Arts Vienna, and continues to pursue both. She am a scientist and an artist. After obtaining a PhD in astronomy, she moved to U.K., where she now works as a post-doc research fellow in observational astronomy at the University of Nottingham. As an astronomer, she study how galaxies evolve and how matter in the Universe organises itself as a giant cosmic web. As an artist and curator,

she creates and supports artistic work at the intersection of art and science. Her artistic work is inspired by research as an astronomer, and often highlights human and machine-made errors and mistakes, showcasing the humanity in scientific data. She organises and arranges exhibitions and supports other artists and scientists curious to share and exchange their knowledge and inspiration.

'I believe that if we encourage STEAM thinking we are better equipped to tackle the complex, multi-dimensional problems we are all facing in the world right now.'

Stuart Nolan (PhD candidate LICA Lancaster University, UK)

Touch, Telepathy, and Tango

This paper reports on the author's work as an artist engaging with scientists, technologists, and ethicists and argues that scientifically-literate artists can play a role in shaping ethical frameworks and informing technological futurities.

For 'One Thousand Mindreaders' (2017), the author trained one thousand people in muscle reading, a 19th-century mentalism performance technique that enables the practitioner to determine what action someone is imagining by feeling the micro-muscle movements in that person's arm caused by ideomotor responses to their kinaesthetic imagination. Participants would learn to find objects other participants had hidden and duplicate drawings they were merely thinking about. Artists, designers, technologists, and scientists participated in 38 workshops, performances, and exhibitions throughout Europe and the US at 31 venues including GoogleX and Digital Science. This resulted in a series of collaborative works involving touch, drawing, and movement.

This kinaesthetic emulation/revision of a contested, non-traditional, institutionally excluded performance art practice made visible various novel perspectives on touch, embodied cognition, contagion, privacy, isolation, surveillance, neuroexistentialism, neurocentrism, and the telepathic sublime.

These perspectives contributed to a collaborative anticipatory ethics of neuroscientific futurity, directly informing the author's ongoing work on the IEEE Neuroethics Framework, developing guidelines to address ethical, legal, and social concerns for the research and use of neuroscience.

The paper argues that an artist's involvement with science can go beyond the making of artworks that respond to science and can directly influence the production of science itself through a novel, informed, and critical engagement with ethics and policy-making.

Bio: Stuart Nolan is an AHRC-funded PhD researcher at LICA Lancaster University, developing performance and visual art approaches to the anticipatory ethics of neurotechnology. His work combines traditional disciplines of deception with innovative and questionable technologies that have recently included a mindreading robot bird, an AI that believes in magic, and a device that makes a person's arm invisible. He has been featured in BBC Click, The Guardian, and Wired. His show, 'Season of Sleeps', premiered at the Swiss Consulate for the 2015 Venice Biennale. Stuart is a co-founder of the Magic Research Group, Huddersfield and a co-editor of *The Journal of Performance Magic*. Formally a NESTA Fellow in Applied Magic and a Magician in Residence at Pervasive Media Studio. He has been a technology innovation consultant and assessor for Innovate UK for the past 10 years.

Cecilia Oliveira (Institute for Advanced Sustainability Studies, Potsdam, Germany)

Bio: Cecilia Oliveira holds a Ph.D. in political science from the Catholic University of Sao Paulo and her research areas are international relations, development, climate and security studies. At the Institute for Advanced Sustainability Studies (Potsdam), she leads a research project for climate studies in the Amazon region and the research group Democratic Re-Configurations of Sustainability Transformations. She is originally from Brazil where she also developed research on dance, Brazilian traditional culture and performance.

Stephanie Owens (Head of School of the School of Arts + Media at Plymouth College of Art, UK)

The invisible co-created and the phenomenal aesthetics of polymers

My paper begins with a close examination of artist Kimsooja's Needle Woman: Galaxy was a memory, Earth is a souvenir (2015), a 46-foot sculpture made of an iridescent nano polymer created with materials scientists at Cornell University (US). I commissioned the project and worked closely with the artist and researchers in materials nanoscience for two years.

Answering one of the questions posed by your symposium, the sculpture was not a result of planned outcome of the collaboration, but emerged out of a shared, speculative process that openly explored the cultural and critical possibilities of molecular design as an artistic practice.

The idea that an artist might work at the molecular or nano scale of matter, while not unfamiliar, nonetheless means that an artist can now create form through a process not accessible to unaided sight, working through an physical and social interface that makes the humanly invisible registers of form visible. This goes largely against what all artists and designers normally do--which is to develop strategies for creating representative or expressive adjacencies —colors, lines, textures that relate harmoniously or discordantly on a visible surface or volume. Working at a nanoscale, artists have to consider cause and effect, using the causal as a field within which to express ideas and novel morphologies.

In my paper, I use my work in realizing the Needle Woman project to demonstrate how a significant cultural project can emerge at the interface of art and science without an instrumental bias of known objectives. Instead, if there is a common experience (in our case a focus on the structure of light) and an intentionally open, co-creative process, collaborations between art and science can result in an expanded understanding of both disciplines and offer a new post-representational aesthetic that better expresses a world in flux.

Bio: Stephanie Owens is an interdisciplinary artist, creative researcher, and curator interested in the influence of digital networks on contemporary aesthetics and the production of subjectivity. From 2011-2017 Owens was Director of the Cornell Council for the Arts (CCA) where she organized Cornell's first art biennial focused on intersections between art, design and nano science which was the subject of 'Collaboration on Campus: Nanotechnology and Contemporary Art ', a documentary by Art21. She is a founder of Mobile Geographies , a locative-media initiative at Parsons The New School for Design (NYC) and co-founder of the storefront new media art space MediaNoche (NY), the first artist-run gallery for digital art in Upper Manhattan. Some of Owens's curatorial projects include Technologies of Place, funded by New York Foundation for the Arts, SELF[n]: Art & Distributed Subjectivity, Intimate Cosmologies: The Aesthetics of Scale in an Age of Nanotechnology (Cornell University), and Abject/Object Empathies (Cornell University).

Owens exhibits her work internationally including recent exhibitions at the First Beijing International Media Arts Exhibition (Beijing, China), Dashanzi Art Festival (Beijing, China), 5th Ewha Media Art Exhibition, (Seoul, Korea) and the Machinista International Arts and Technology Festival. Frequently a speaker on art and technology, she recently presented papers at College Art Association (CAA), SIGGRAPH (Los Angeles) and Consciousness Reframed: Art, Identity and the Technology of Transformation (Lisbon) and was the artist-in-residence in 2018 at COPE in Brooklyn, NY. In 2019

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Owens was appointed Head of School of the School of Arts + Media at Plymouth College of Art, Plymouth, UK.

Pat Simpson (Reader, University of Hertfordshire, UK)

Revolutionary Evolution in Apes and Humans in the 1920s: Sculpture and Constructs of the 'New Man' at the Moscow Darwin Museum

This chapter explores the contemporary contextual and ideological resonances of a pair of sculptures entitled Age of Life, commissioned by the Darwin Museum in Moscow from the sculptor Vasilii Vatagin in 1926, in relation to discourses relating to aspects of the historical and contemporary constructs of the 'New Man'. The sculptures, which now reside on the 2nd floor gallery of the Darwin Museum, represent the stages of life and modes of sociability in humankind and amongst orangutans. Overall, the argument suggests that in relation to their context of production, the representations projected The by the sculptures can be argued to respond, in a self-interested way on the part of the Museum, to a complexly interwoven set of key contemporary discourses on: Lamarck, Darwinism, eugenics, 'hygienic maternity', and competing bio-scientific possibilities of 'evolutionising' anthropoid apes in the USSR. chapter concludes that, by doing so, the sculptures also implicitly present images of both apes and human women as 'docile bodies', a concept formulated by Michel Foucault regarding the exertion of institutional and political bio-power over citizens - and in this case also over creatures as well - which was implicitly essential to the evolution of the 'New Man' in contemporary terms.

Bio: Dr Pat Simpson is Reader in Social History of Art, and Research Tutor at the School of Creative Arts, University of Hertfordshire, UK.

Lisa Taliano and Maria Patricia Tinajero (NY, USA)

Porous Borders, Toxic Landscape: Mapping The Massena Critical Zone

How do we envision new ways to live within the altered world? In these unprecedented times of climate transformation and irreversible ecological alterations, the problems we face are so new and complex that only through our combined efforts in art, science, activism, and theory can we understand and bring about the changes needed to achieve an ecologically sound worldview and learn to live and prosper with the damage. Our transdisciplinary environmental health and justice eco-art project maps the activity and interactions of the living and non-living entities that make up a small town as they jointly create the critical zone. It is a way of engaging art in a new science that understands its entanglements within political, sociological and economic structures. In this presentation, we will discuss our methodology, fieldwork, and interactions with government officials, public health experts, and concerned citizens in a community in northern New York that has been home to three of the worst hazardous waste sites in the US. The goal in focusing on this microcosm is to understand and map

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the interchanges that have shaped the landscape and the people of Massena by extension in order to assess the damage and envision new ways forward.

Combined Bios: We are practicing visual artists in painting and sculpture, currently working on a collaborative ecological research project on ecological imaging: Mapping the CZ in the City, which will culminate in a collaborative set of art events, October 2020 in NYC. We've published and presented in the field of ecological art and philosophy. Our papers were part of the Symposium 'Artists and the Philosophers We Love' (June 2019) at the University of Hertfordshire, UK. Taliano's 'Disorientation Re-presentation"'and Tinajero's 'Ethical Grounds: The Aesthetic Action of Soil', published in the anthology *Art, Theory and Practice in the Anthropocene*, edited by Julie Reiss, at Vernon Press, 2019.

Taliano maintains an artistic practice in NYC. She received an MFA from Boston University and an MA in Philosophy from Indiana University. Her curatorial projects include: 2019-2020, exhibition and catalogue 10 X Relay, in NYC, UT Knoxville, and IU, Columbus; Eating Painting at Project:ARTspace NYC in 2015; and 2013 Sleepwalker in Brooklyn. Tinajero is a visual artist and a PHD candidate at IDSVA. Tinajero has received an affiliate fellowship from the American Academy in Rome (2010). Her work has been exhibited at Museo de las Américas, Denver (2013); Museum of Contemporary Art Valdivia, Chile (2012); Knoxville Museum of Art, TN (2009); Islip Art Museum, NY (2007).