Art and Science as Creative Catalysts

Eleanor Gates-Stuart, *Member, IEEE*, Chuong Nguyen, Matt Adcock, *Member, IEEE*,
Jay Bradley, Matthew Morell and David R. Lovell, *Member, IEEE*

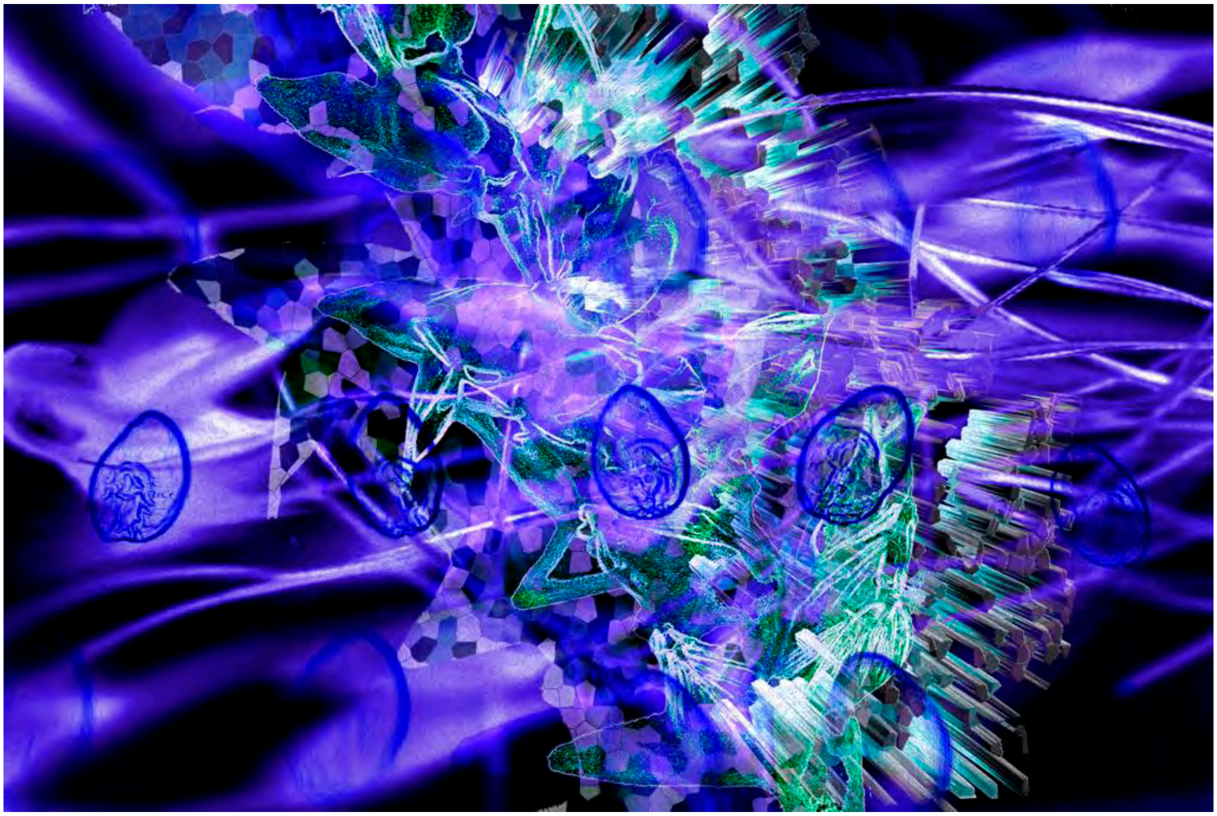


Fig. 1. MAGICal B by Eleanor Gates-Stuart from the MAGICal series (**M**ultiparent **A**dvanced **G**eneration **I**nter-**C**ross [17]).

Abstract—People tend to judge the benefits of Science Art collaborations by their tangible outputs, such as artworks, visualisations and other artefacts generally accessible to a wide audience. We argue that the *p*rocess by which these artworks were created can be a significant, or even the principal benefit of these collaborations, even though it might be largely invisible to anyone other than the collaborators. We describe our experience of Art and Science as mutual catalysts for creativity and imagination within the context of a large multidisciplinary research organisation (The Commonwealth Scientific and Industrial Research Organisation—CSIRO) and a major national exhibition—The Centenary of Canberra Science Art Commission. We have formed a view that Science and Art often pursue orthogonal dimensions of creativity and innovation, and that with the right approach and attitude, collaborators can combine these dimensions to access new areas of imagination and ideas. We discuss some of the challenges we have experienced in pursuing this aim, but conclude that the rewards to Art and Science—and the benefits they deliver to society—are well worth it.

Index Terms—Creativity, collaboration, imagination

1 Introduction

Science and Art are generally presented and understood in terms of their *products*. For Science, these products include the critical breakthrough, the leap of insight, the finished manuscript that tells the steady, logical progression towards a meaningful result. For Art, the product even has a special name: the *artwork*. Yet, that word, that noun formation of *art* (the skill in doing something) and *work* (something that was done, or—if you want to stretch to the verb—to do, to perform, to practice), that word hints at a whole new world that is generally invisible or inaccessible to anyone except the artwork's creators.

Even when Science and Art get together, it's their products that tend to remain centre stage[1]. Indeed, the Centenary of Canberra Sci-

- *Eleanor Gates-Stuart is a PhD candidate at the Australian National University, the recipient of the Centenary of Canberra Science Art Commission and Science Art Fellow at CSIRO.*
- *Matthew Morell leads CSIRO's Future Grains Theme*
- *David Lovell is Director of the Australian Bioinformatics Network and co-Leader of CSIRO's Transformational Biology initiative*
- *Jay Bradley is Software Manager at Pufferfish Ltd. Email: jay@PufferfishDisplays.co.uk*
- *All other authors are with CSIRO. Email: firstname.lastname@csiro.au*

[1]As far as we are aware, these products are more often artworks than "scienceworks", and collaborations tend to be more about Art drawing inspiration

ence Art Commission that has brought us (the authors) together as collaborators specifically requested proposals for the *"Production and presentation of a new work of art for the Centenary of Canberra that symbolizes science achievement in the ACT"* [8].

In this paper, we want to highlight an important part of collaboration that could be easily eclipsed by a purely "product-focused" view of Science Art. Our aim is to capture and articulate aspects of Science Art that have only become apparent to us through our work together and by first-hand experience of interactions, ideas and innovations that would not have happened if scientists and artists had been left to their own devices. We argue that the *process* by which artworks are developed and created in Science Art collaborations can bring significant benefits to the individuals and institutions involved.

We begin by describing our context: the Science Art Commission that brought us together, and the host science institution (CSIRO) that has provided the residency for the artist (Eleanor Gates-Stuart) for the development of the Work. Next, we report some of the collaborations—and their interactions, ideas and innovations—that have been catalysed by this residency, and then propose a conceptual model that, for us, explains why Art and Science can be more creative in collaboration than in isolation. In forming this view, we have had to ask ourselves "How does this process differ from the discipline of science communication? Or scientific visualisation?" We explore these questions and also some of the challenges we have encountered throughout this process.

2 Context

We would not have gained the insights described in this paper without the Centenary of Canberra Science Art Commission and the CSIRO. The nature of the Commission (Art) and the host institution (Science) are important in providing opportunities for creative connection and interplay (Science Art).

2.1 The Centenary of Canberra Science Art Commission

The Centenary Science Art Commission, supported by the ACT Government and the Australian Government, is a project to celebrate the centenary of Australia's capital city by producing a new work of art that symbolizes science achievement in the ACT. The Commission was awarded to Canberra artist Eleanor Gates-Stuart for her proposal *StellrScopε*, a term coined to describe the translation of complex information into a simpler visual rendering of meaning accessible to non-scientists.

The scientific achievements that Eleanor chose to focus on relate to wheat, an organism whose evolution is intertwined with our own, and whose history is connected to the Canberra region from the 1800s—the time of William Farrer ('father of the Australian wheat industry') through to today's bioscience research at CSIRO.

Wheat provides an incredibly broad palette of ideas: evidence of its domestication stretches back millenia; it is the leading source of vegetable protein in our food; and the science behind its development and cultivation embraces not just biology but information sciences, including statistics (which owes much to the work of Ronald Fisher at Rothamsted Experimental Station), computational science and bioinformatics. For the artist wielding that palette, the challenge is how to represent 100 years of meaningful content in a singular artistic outcome for the Centenary of Canberra, as well as an artwork with equal value and understanding for CSIRO.

2.2 The CSIRO

CSIRO, the Commonwealth Scientific and Industrial Research Organisation (`www.csiro.au`) is Australia's national science agency. Originally formed in 1926 as the Council for Scientific and Industrial Research, CSIRO today fields more than 6500 staff located across 56 sites throughout Australia and overseas, working to deliver benefits from science in areas including climate, water, health, energy, food and more.

Fig. 2. Architectural projection onto Canberra's Questacon building by Eleanor Gates-Stuart as part of the 2013 Enlighten Festival.

CSIRO has a major presence in Canberra which includes CSIRO Plant Industry, CSIRO Computational Informatics, and the High Resolution Plant Phenomics Centre, each of which makes important contributions to wheat research and development. As an institution, CSIRO also has a long history of supporting the productive interaction of Science and Art, through commissioned works, exhibitions and events [12].

Within Australia's National Innovation System, CSIRO aims to occupy a special place by fielding large-scale, long-term multidisciplinary science to address major national challenges and opportunities. (The Food Futures Flagship exemplifies this kind of effort, and its Future Grains Theme is a key supporter of *StellrScopε*.) However, the breadth of its research and the geographic spread of its researchers makes this a challenging aspiration; communication *within* the organisation and *between* the research disciplines it houses is critical to success. In 2008, CSIRO initiated its Transformational Capability Platform (TCP) program with the explicit intent of fostering vital cross-organisational science areas; the Transformational Biology TCP has provided the residency for Eleanor Gates-Stuart.

3 Collaborations

The five collaborations described in this section are a sample of the interactions, ideas and innovations catalysed by Eleanor Gates-Stuart's residence in CSIRO. Even though this residency came about through a Commission whose focus is on wheat, some of the products of these collaborations are not obviously wheat related. The connections to wheat lie in the collaborative *process*. In the same way that Edmonds *et al.* described [15], the case studies we present illustrate *"...how, in creative work, exploratory ideas and acts arise* during *the process and sometimes as side effects rather than from the explicit objectives being pursued at the time."*

This section names many people, both for accurate attribution and to illustrate the breadth of relationships and disciplines that can be connected through Science and Art.

3.1 Bugs on Buildings

One of Eleanor's first tasks in the residency was to explore the diversity of scientific research taking place at CSIRO in Canberra. Based

from—or commenting upon—Science, than *vice versa*.

Fig. 3. Broad-nosed Weevil (*Gagatophorus sp.*) by Eleanor Gates-Stuart in collaboration with Chuong Nguyen and Sherry Mayo. 3D-printed in titanium by CSIRO Titanium Technologies.

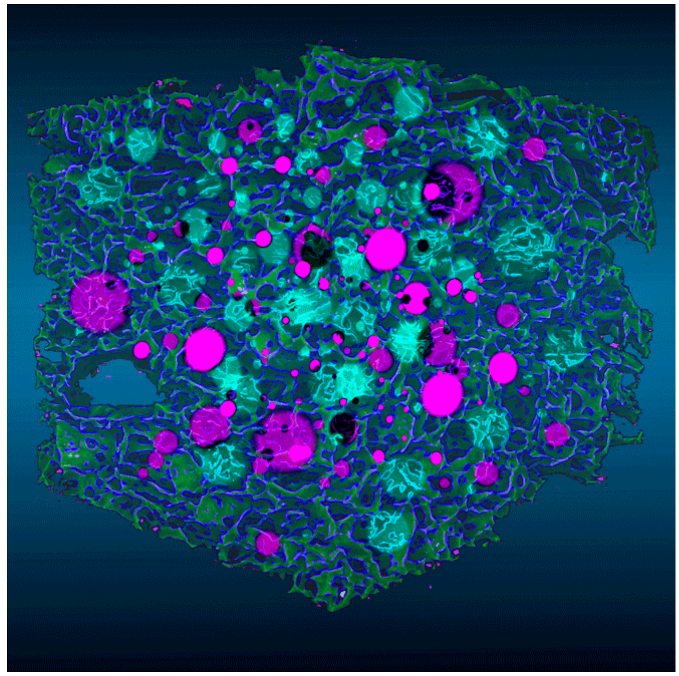


Fig. 4. Invisible Bubbles by Eleanor Gates-Stuart in collaboration with Sherry Mayo and Sumana Bell.

at the Division of Mathematics, Informatics and Statistics (now Computational Informatics), Eleanor soon met Dr Chuong Nguyen whose postdoctoral research deals with the capture and recovery of optical 3D models from multiple 2D images. (Here "optical" refers to acquisition of the visible characteristics of the surface of the object being imaged, in contrast to volumetric imaging methods like computer tomography (CT) which do not capture surface colour.) Chuong's research is motivated by the desire to acquire information *non-destructively* about the structure of living (or once-living) specimens for application in phenomics, biosecurity and taxonomy.

Chuong had developed a low-cost portable capture rig, suitable for small (millimetre-scale) specimens, and built from off-the-shelf components. This work was already a creative blend of science, engineering and design considerations which, among other things, addressed the desire to make a system that would be affordable to researchers, such as staff from the Australian National Insect Collection [10] who worked in close collaboration with Chuong. Initial tests were promising but there was room for improvements in reconstruction accuracy.

The typical scientific publication path would have been to work on refinements to the system until a level of accuracy had been achieved sufficient to warrant journal publication. However, Eleanor and Chuong both saw the *artistic* potential of the models that the prototype could capture, realising that the accuracy of the reconstructions was more than "good enough" for (artistically) creative purposes.

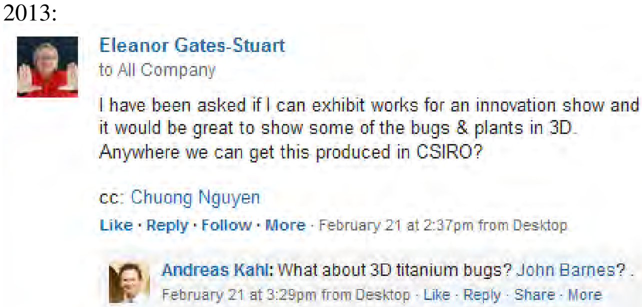
This interplay between Art and Science led to a number of large-scale works, including architectural projections by Electric Canvas [24] featured at the 2013 Canberra Enlighten Festival [7] and seen by thousands [11]. Like many other research organisations, CSIRO seeks to raise public awareness of science, yet science culture places a strong emphasis on peer-reviewed publications in journals that garner a focused and relatively limited readership. Here Art and Science catalysed works of artistic merit that enabled scientific research to reach a larger audience.

3.2 Titanium Bugs

It is no surprise that, as one of the most diverse groups of animals on the planet, insects figure highly in the production of one of the world's major food crops. Eleanor's discussions with Zimmerman Fellow in Weevil Research, Dr Rolf Oberprieler, highlighted the impact of the wheat weevil (*Sitophilus granarius*) on stored grain. At 3-5mm long, this species provided some of the motivation for the optical 3D model capture system that Chuong was to later develop however, at the time, attempts were made to achieve a low-cost alternative to CT scanning by digitally reassembling thin 2D sections obtained via microtome. (The internal structures of weevils and some other insects are of interest for many reasons, including taxonomic: in some instances the architecture of internal genitalia are a key discriminative character between species.)

Described as "built like a tank", *Sitophilus granarius* did not yield its secrets to the microtome—specimens tended to explode during sectioning. This led Eleanor to contact Dr Sherry Mayo, Senior Research Scientist in CSIRO's X-ray and Synchrotron Science and Instruments team, who graciously scanned a specimen in the Australian Synchrotron and rendered it using Drishti [20].

An important part of Eleanor's residency has been to communicate her progress. External to CSIRO, `www.StellrScopE.com` is a key channel for doing this; internal to CSIRO, Eleanor has used Yammer [27] to good effect. The following exchange took place on 21 February 2013:



About an hour after Eleanor's initial post, a fellow CSIRO employee whom she had never met, had, from a different city, sparked a connection with John Barnes, Titanium Technologies Theme Leader. This led to a collaboration involving entomology, synchrotron science, computer vision and 3D reconstruction (additional work had to be done to re-sample the surface mesh constructed from the synchrotron scan), and 3D printing in titanium.

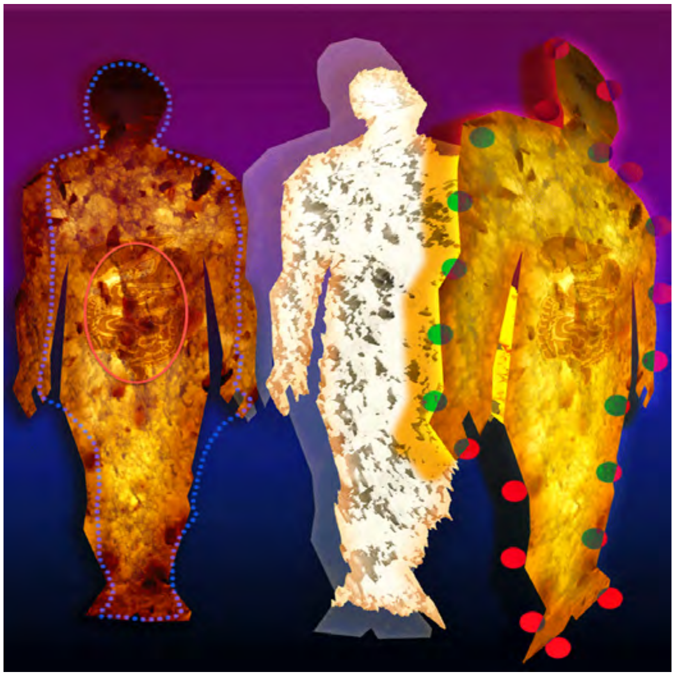


Fig. 5. Bread Man by Eleanor Gates-Stuart. Unfortunately, we lacked the time and the dough to make him for *StellrScopε*.

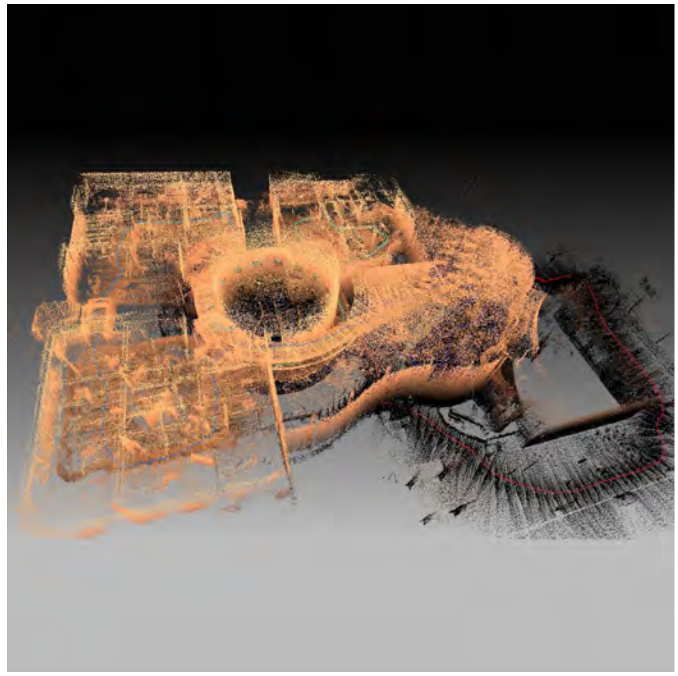


Fig. 6. Point cloud of the interior of the Questacon building, captured by Elliot Duff and Jonathan Roberts using Zebedee [5].

The first 3D titanium insects to emerge from the printer had some surprising properties (at least to those who had not previously seen 3D titanium printing before): the surfaces of the insects had a roughness similar to very fine sand; the insects looked a fairly dull grey; and despite their apparent delicacy and fine structure, each insect remained "built like a tank". The last property was an obvious plus, but it took a little more time to appreciate the first two. It was only when the titanium bugs were placed and moved under illumination that the jewel-like quality of their surfaces revealed itself. The facets of the tiny grains of titanium sintered together in the printing process created an almost iridescent effect, reminiscent of, but different to the micro- and nanostructures found in real insects (see, e.g., [13]).

As with the Bugs on Buildings, this collaboration generated considerable publicity (which, in turn has led to further enquiries about the underlying research and methods) but from the perspective of a multidisciplinary science organisation, one of the key benefits of the Science Art collaboration process has been to make connections between researchers from disparate fields: entomology, computer vision, tomography, materials science.

3.3 Invisible Bubbles

Science quickly reminds us that our ability to perceive the Universe is limited to the narrow band of our senses. However, human ingenuity has produced devices and methods to extend our perception by transforming the "invisible Universe" into the realm of our senses.

At the beginning of her residency, Eleanor presented Dr Matthew Morell, Future Grains Theme Leader and *StellrScopε* sponsor, with some initial sketches. The ensuing conversation was along the lines of
MM: *Why are you bringing me pictures of wheat plants?*
EGS: *What would you have brought?*
MM: *Pictures of holes. Holes are one of the most important things in bread.*

Around that time, Dr David Lovell, Transformational Biology co-Leader and *StellrScopε* sponsor, was introducing Eleanor to the multiple dimensions and multivariate methods underpinning aspects of experimental design and analysis in field trials and wheat breeding. Eleanor had been exploring moving from 2D visuals into 3D; now with the help of Abbot [3], she was gaining an entrée into the n^{th} dimension.

While it is possible through projection and animation to glimpse aspects of higher dimensions, it is not clear that humans have the capacity to fully comprehend or form accurate mental models of high-dimensional data. However, a less representational (and less objective) approach, a more artistic (and more subjective) approach to rendering this data can yield dividends by *alluding* to information that lives in high dimensions. This strategy led to the MAGICal Series (see Figure 1) in which MAGIC stands for Multiparent Advanced Generation Inter-Cross [17], a breeding strategy aimed to explore the genetic and phenotypic diversity of an organism.

When this abstract representation was presented at a Future Grains workshop, Dr Sumana Bell (Research Director at the Centre for Grain Food Innovation) saw the potential to apply these ideas to the "invisible bubbles" of gas inside bread [25]. Following further discussion at OzViz 2012, links were made to Sherry Mayo who has since used X-ray CT to gain insight into the voids that form during dough development, and which determine texture, consistency and baking properties. This joint research between Sumana and Sherry is a work in progress, and it neatly illustrates how Art can catalyse Science and foster interactions across research domains (see Section 5.2).

3.4 Bread Man

One extremely valuable role that artists can play in Science and with scientists is *to ask questions*. Even though Science is at heart a questioning process (hence the term "scientific inquiry") it is easy to lose sight of some of the basic questions that motivate more detailed and specific research.

"Why should we eat bread?" is one such question that Eleanor posed to Matthew who, among other things, cited benefits to digestion, particularly with grains high in resistant starch. Reflecting on this point later, Eleanor conceived of "Bread Man", a man-sized, man-shaped loaf that could be sliced to reveal aspects of the human digestive system.

Enquiries were made at a major commercial bakery and, after being convinced that these were in fact serious, practical challenges were raised, including uniformity of baking and the risk of Bread Man's thinner parts burning while his thicker regions remained doughy. In the end, concerns that this venture may not enhance the professional reputation of the bakery meant things went no further. Thoughts then

Fig. 7. Rendering of the *StellrLumé*/PufferDome concept by Eleanor Gates-Stuart and Pufferfish Ltd.

turned to how Bread Man could be baked in-house.

Be they scientists or artists, creative people generally love a challenge; this one triggered a late afternoon of brainstorming as to how the bread could be baked in the required shape (we settled on two "half-man" bread tins), how these tins could be made (full-body casting was suggested), and how the loaf could actually be baked (the services of a local crematorium were very briefly contemplated). Later, Chuong tackled the problem of acquiring a full-body 3D model to be used as the basis of a mold; he conceived and quickly built a low-cost prototype using a pedestal, two Microsoft Kinect Depth Cameras and KinectFusion [18]. As for the fabrication of the loaf tins, we approached Robert Foster—local designer, metalsmith and principal of the internationally acclaimed F!NK Design [1]—who suggested a practical strategy, along with a less controversial approach to baking using some nearby industrial ovens.

In the end, time and other constraints meant that Bread Man would not be baked for *StellrScopε*, but some of the by-products of the creative process—particularly the low-cost full-body scanner—demonstrate how Art can pose challenges that take Science, Engineering and Design in new, and potentially useful directions.

3.5 *StellrLumé*s and PufferDomes

The last collaboration we describe in this paper is about the centrepiece of *StellrScopε*, an exhibit to be displayed at Questacon, the Australian National Science Centre.

Expectations were (and still are) high—*"Show me the 'Wow!' factor"* were the words of a key stakeholder, absorbed viscerally by all involved in *StellrScopε*'s production. At the time of writing, the exhibit is still in production and, whether it delivers the anticipated reaction remains to be seen. One thing is clear in this regard: eliciting a "Wow!" seems to involve a degree of risk—in this case, largely technical and logistical. Philosophically, this speaks to the experimental nature of Art and Science and their desire to "push the envelope".

To begin with, *StellrScopε* was to be exhibited in Questacon's large atrium. Thoughts quickly turned to projection; the irregular walls of the atrium were an obvious challenge but also an opportunity to use CSIRO's technology. Thanks again to Yammer, Eleanor was already familiar with the Autonomous Systems Lab's Zebedee flying-spot laser scanner [5]. A chance encounter with Brisbane-based 3D-mapping experts, Dr Elliot Duff and Dr Jonathan Roberts from CSIRO's Autonomous Systems Laboratory, opened up a way to acquire a model of the atrium as a precursor to architectural projection. When Eleanor bumped into them after they had been scanning CSIRO's headquarters in Canberra, she asked whether they would mind "nipping over to Questacon and scanning the atrium?" Two hours later, the job was done in time for the flight back to Brisbane.

As a LiDAR device, Zebedee returned data about Questacon as a point cloud, a very large point cloud (Figure 6) from which a surface had to be inferred as a triangulated mesh. Before addressing this challenge, plans to use projection inside the atrium were scotched: available projectors simply could not deliver images bright enough to outdo the ambient light. Holding *StellrScopε* at night *inside* Questacon was not an option. We had reached a dead end.

Inspiration came to Eleanor from an unlikely source: a *Top Gear* documentary on the cars of James Bond [2] in which presenter, Richard Hammond, renders a van (almost) invisible using a large flat-screen on one side of the vehicle to display the scene on the other side. Instead of projecting onto a suface from "the outside", Eleanor wondered about projection from "the inside", containing the light, creating a luminous object that could generate sufficient brightness to be visible against ambient light.

This idea triggered research and—via interactive-augmented-reality specialist Matt Adcock—consultation with Drs Tomasz Bednarz and Con Caris (CSIRO) and Associate Professor Paul Bourke (Director of iVEC at UWA). We began to settle on an idea we named a *StellrLumé*: a projection inside a translucent hemisphere of a size that people could stand around or perhaps even interact with.

We learned of Pufferfish Ltd., an Edinburgh-based company specialising in interactive spherical displays (PufferSphere®) and found out that one had recently been installed in the new National Arboretum in Canberra. By chance, Will Cavendish (Pufferfish Chief Technical Officer) was just leaving Canberra and a brief meeting was arranged. Will was enthusiastic about the concept, noting that a hemispherical display about require research and development at Pufferfish.

Like all projects, *StellrScopε* has constraints, most obviously: time and money. Now we were preparing to increase the project's risk by using a novel display device that had to be designed, built, shipped and installed in a very short time. Other factors came into play, such as display brightness and resolution, as well as less technical issues including the release and transfer of funds, exchange rate fluctuations, accounting rules about capital expenditure, and managing stakeholder expectations. Taking everything into account, we engaged Pufferfish to fabricate two "PufferDomes" as envisioned in Figure 7.

We still had one big challenge to resolve: how could this display device deliver content that people (possibly *many* people) could interact with? Matt Adcock proposed an innovative, practical solution that reinforced Eleanor's artistic practice of layering images and information. An overhead Kinect depth camera would relay information about objects (e.g., hands) placed over the hemisphere; this "virtual shadow" data would be used to mask one video stream projected on to the hemisphere to reveal a second different video stream. In effect, people could cast shadows onto the hemisphere yet, instead of causing an *absence* of illumination, these shadows would reveal the *presence* of a new, precisely registered and synchronised layer of imagery.

At the time of writing, the *StellrLumé*s/PufferDomes, the Kinect-based interaction of video layers, and the actual display content are at the outer edge of the production schedule. All parties are working extremely hard to deliver the "Wow!" factor on time. Stepping back from this nail-biting situation, this final case study shows not just the creative interplay between Science and Art, but also Design and Engineering—four aspects of creativity that we shall discuss shortly.

4 Conceptualisation

Our experience of the *process* of Science Art collaboration in *StellrScopε* has been extremely positive. It has brought people together who would not otherwise have met; it has sparked insights that would not otherwise have been glimpsed; it seems to have liberated

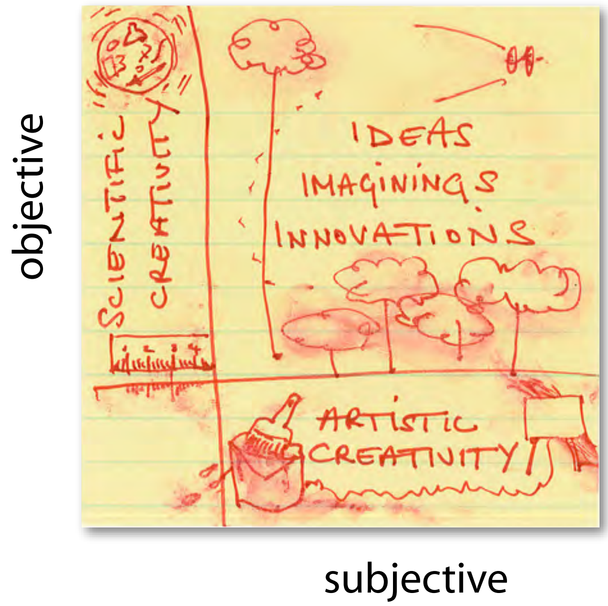


Fig. 8. Our conceptual model of the constructive connection and interplay between artistic creativity (which deals in *subjective* interpretation) and scientific creativity (which deals in *objective* interpretation). When these two orthogonal dimensions of creativity connect in a Science Art collaboration, the collaborators gain access to new realms of ideas, imagination and innovation.

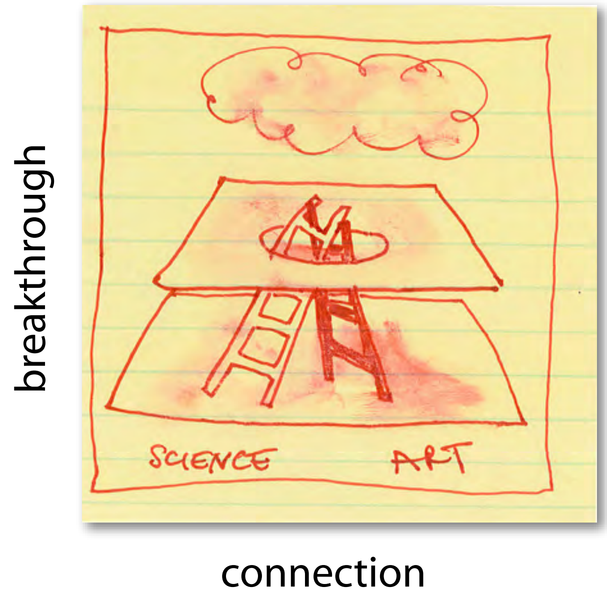


Fig. 9. A visual metaphor for what can be achieved when the orthogonal dimensions of scientific and artistic creativity connect.

people to think in ways that they would not have otherwise entertained. These experiences have been felt by scientists and artist alike.

As we examined this situation for clues as to why this may have happened, we felt we had experienced a constructive interplay between *scientific* creativity and *artistic* creativity, and we conceptualised this model as shown in Figure 8. Our model posits that, in isolation, scientific and artistic processes pursue orthogonal "directions" of creativity but, in combination, they allow their participants to access new areas of ideas, imagination and innovation.

We recognise that there is a significant body of theory on creativity and we do not claim to be experts in that domain; we shall try to relate the model of our experiences to existing theories and definitions as best we can. In our model,

creativity refers simply to the *generation of ideas*. Burbiel [6] has surveyed a range of models of creativity and, himself, described the creative act in two stages: *idea generation* and *idea validation* stating that *"In artistic settings, the first step is a value in itself and validation is not that essential"*. Amabile [4] qualifies creativity in business in a similar way saying that *"originality isn't enough. To be creative, an idea must also be appropriate—useful and actionable."*

scientific creativity refers to idea generation that changes the *domain* of Science. Here, we borrow from Csikszentmihalyi's systems model of creativity [9] in which a *domain "...consists of a set of symbolic rules and procedures. Mathematics is a domain, or at a finer resolution, algebra and number theory can be seen as domains. Domains are in turn nested in what we usually call culture, or the symbolic knowledge shared by a particular society... "* One of the hallmarks of scientific culture is its desire to be *objective*, *"not influenced by personal feelings or opinions in considering and representing facts; impartial, detached "* [21] or, as Daston and Gallison put it [14], *"to aspire to knowledge that bears no trace of the knower."*

artistic creativity refers to idea generation that changes the domain of Art. Here, it is important to mention Csikszentmihalyi's concept of the *field* [9] *"which includes all the individuals who act as gatekeepers to the domain... It is this field that selects what new works of art deserve to be recognized, preserved and remembered."* In contrast to Science, Art (like Beauty) is in the eye of the beholder and it is accepted that works of art will receive *subjective* interpretation.

As we started writing about this model, one of us (DL) was reminded of an old puzzle about crossing a square moat around a square island given only two planks, bot of which a just short of the width of the moat. The answer involves a combination of both planks to get to places they could not reach on their own. After discussion, EGS came up with Figure 9 which is a much better visual metaphor for the breakthroughs that can arise when Science and Art processes connect.

Successful collaborations between Science and Art presume some human factors not explicitly shown in Figure 9: the right approach and attitude from the collaborators. Hudson *et al.*[19] set this out well by commenting that

> *...successful cross-disciplinary collaboration requires individuals whose enthusiasm is sparked by a process of problem solving and question asking and whose personalities have a tolerance for risk and time spent in having to incorporate a multiplicity of practical, aesthetic and conceptual requirements.*

5 Critique

Having stated a model of our experience of the process of Science Art collaboration we now take a critical look at that conceptualisation and related ideas.

5.1 Four hats: Art, Science, Design and Engineering

The "four creative hats" (Figure 10) described by Rich Gold [16] and discussed by Pausch [22] add further richness to our model of creative interplay between Art and Science. Gold sees common ground in that *"artists are like the scientists, looking for, dare I say it, Truths, even if only personal ones."* He also sees differences in that *"works need to be unique from artist to artist... Replicating art does not 'prove' it."*

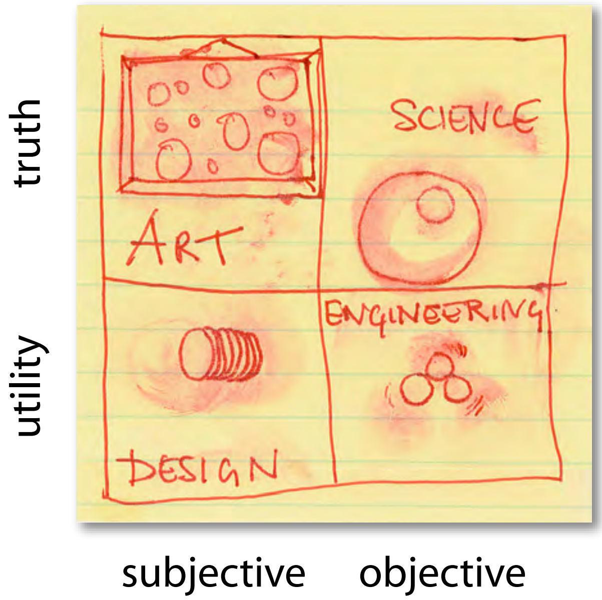


Fig. 10. The sketch in this Figure is Gold's representation of the "four hats of creation" (redrawn by EGS). The printed annotations are (mostly) our own words—Pausch [22] labels the top and bottom halves "search for truth" and "problem solving," respectively, and the left and right halves "those who can draw" versus "those who can do math."

Our conceptual model of Science Art collaboration would probably not have come as a surprise to Gold for, as Marina de Bellagente LaPalma writes [16, p.xv]:

> *The intellectual divide (articulated in C.P. Snow's 1963 book) between the cultures of science and the humanities simply did not exist for Rich.*

To Gold, the biggest schism is not between Science and Art, but between the "truth-seeking" cultures (science/art) and utility-driven design/engineering.

As far as our experiences in *StellrScopɛ* are concerned, we have not encountered any serious divides between the four quadrants in (Figure 10), possibly because project participants have backgrounds in more than one domain (e.g., art/design (EGS), science/engineering (DL and MA)). Certainly, we have had to wear all four hats to make practical progress. One thing we have experienced is evidence of cultural divides *within* Science...

5.2 Cultures: from two to *n*

Collaboration can be a great leveler for researchers—so much so that some shy away from it. An expert in one field can quickly cross disciplinary boundaries to become a novice in another. C.P. Snow's description of the mutual ignorance and lack of appreciation between two cultures [23], and models like those in Figures 8 and 10 are suggestive of those divisions.

However, our experience—particularly within the multidisciplinary environment of CSIRO—suggests that there are far more than two cultures to be mindful of. Weibel [26] pointed this out when he wrote

> *...there are not only two worlds, but n worlds, chemistry, mathematics, crystallography, physics, etc., ... not only the world of art and science, because it would be likewise difficult to find an individuum which is a professional expert in molecular biology, proof theory and physics, or an individuum which is at home thin the arts and in the sciences. The universe of science is separated into many subuniverses very similar to the separation of art and science.*

In *StellrScopɛ*, Art has been like a ticket to—and passport between—several Science cultures, including plant science, entomology, materials science, computer vision, bioinformatics and X-ray imaging. It could be argued that these sorts of collaboration arise naturally within Science and research organisations as problems arise that demand multidisciplinary solutions. But time and again, we saw how an approach from an artist engaged scientists of different persuasions in a uniquely disarming way. Gone was the wariness, the *"yes... what do you want (from me)?"* that can appear in response to approaches from other scientists, replaced instead by animated and enthusiastic discussion, generally concluded by enquiries of *"how can I help?"* True, this says a lot about the approach of the artist, but the opportunity to talk about Art and Science seemed to generate interest and engagement from scientists at levels that should warrant attention from anyone, or any institution, seeking to foster multidisciplinary research.

5.3 What this model is not about

Sometimes, the most effective way to clarify the scope of an issue is to state what it *could be* but *is not* about. In this paper's description of Art and Science, we are not referring to

science communication: in our experience, science communication aims to report or disseminate information about science to a wider audience—usually the general public—in an appealing way. The process we describe catalyses communication and understanding *between* researchers in different domains. We believe that science communicators are also well placed to play such a catalytic role, but the culture of science communication—and perhaps scientists' attitudes and perceptions—do not seem to encourage this.

science as inspiration for art is definitely a facet of the Science Art process but, on its own, is insufficient to characterise the dialogue between participants and connections between research domains that we have observed.

artistic use of technology: again, with no requirement for dialogue or connections between research domains, this is not what we are addressing in this paper. That said, we note that the entertainment industry has had a profound impact on research in the information sciences, and vice versa.

scientific visualisation is *almost* in scope, but has a commitment to *representational veracity* that leaves little room to explore the subjective dimensions of artistic creativity.

On this last point, we have observed differences in some people's reactions to scientific visualisation versus Science Art. In our experience, non-specialists often feel intimidated by the detail and technology behind the images commonly used in science; this makes it difficult to get a conversation going about what science is being done, and why. However, everyone (correctly) thinks they have a right to an opinion about an artwork, and are usually happy to discuss their view. This opens the door to explore the layers of meaning in an work of Science Art, allowing not only artistic elements and intent to be discussed, but also the concepts and the purpose behind the science.

Scientific visualisation can stop a conversation about Science; Art can *start* one.

6 Challenges

Throughout *StellrScopɛ* we have encountered many challenges, not just creative ones. Among these, we note

landing the flight of ideas: this paper is all about the interplay between scientific and artistic creativity to open up new ideas—in a successful collaboration, many will be generated. Even though we defined "creativity" in terms of *idea generation*, idea *validation* becomes important in determining which of many possibilities can (and will) be realised, or at least pursued

different drivers, different goals: we suspect the intrinsic motivation to participate in the creation of Science Art is high for many people. Still, it is important to recognise that there are often different *extrinsic* rewards or goals driving different players, e.g., for scientists and for artists, peer recognition demands the production of different kinds of "publications."

IP and creative rights can be challenging enough to negotiate in Science or Art alone. While too heavy an emphasis on "who owns what" can stifle creative interplay, assuming that the products of Science Art collaborations can be handled well by standard scientific or artistic IP practices is risky. Consider, for example, a work that requires ongoing collaboration (e.g., specialised support and maintenance) to be shown, or an Art Science collaboration that directly generates commercially valuable IP. Some of these issues can be covered in the employment contracts of scientists and artists working for the same organisation. Outside that kind of agreement, we see plenty of scope for ownership difficulties.

7 Conclusions

We hope that some of the enthusiasm and energy we have experienced through *StellrScopε* comes through in this paper: it is certainly motivated by a desire to raise awareness of the complementary roles that Science and Art can play in the creative process. And, while the case studies we have presented are rooted in a specific context (The Centenary of Canberra Science Art Commission, and the CSIRO), our aim is to have presented them in ways that can be generalised to other artistic and other multidisciplinary science settings.

Acknowledgments

The Centenary Science Art Commission *StellrScopE* is a Centenary of Canberra project, supported by the ACT Government and the Australian Government. Eleanor Gates-Stuart's residency at CSIRO has been supported through the CSIRO Transformational Biology initiative and in association with CSIRO's Future Grains Theme. We gratefully acknowledge all those who have contributed to, or collaborated with us on the works described in this paper, including ANU students David Feng and Dulitha Ranatunga who played key roles in implementing software and display systems for *StellrScopε*.

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