Art in the Science of Complex Systems

Karen Cham and Jeffrey Johnson
Department of Design and Innovation
The Open University, Milton Keynes, MK7 6AA, UK
k.l.cham@open.ac.uk and j.h.johnson@open.ac.uk

Abstract

We ask *what contribution can art make to the science of complex systems,* and whether *art can become part of the scientific process*. An example is given where art becomes a powerful instrument for data collection, enabling subjects to provide information on their social systems that cannot be elicited using other methods. There are many similarities between art and science, especially in their common concern with representing objects and ideas, and finding new ways of thinking about things. We discuss art in the context of the conflicting modes of thought: discovering truths about systems from the outside or creating narratives and telling stories about systems from the inside. We report on experiments generating artworks to explore the interaction between complex systems science and art. In this context we make a series of predictions to investigate the inside-outside dichotomy. Our conclusion is that art can contribute to science and it can play a powerful part in the science of complex systems.

1. Introduction

We ask the question: *what contribution can art make to the science of complex systems?* This is not the question of how art can be seen through the lens of complex systems. It addresses the much more important issue of whether *can art can be part of the scientific process*.

Surprisingly some believe that art can contribute nothing to science, *e.g.* on a recent radio programme[1] the eminent biologist Lewis Wolpert proclaimed with great certainty "art has contributed zero to science historically. … There are all sorts of images from science that can give artists something to work on, but it does not go the other way. … The artist couldn't tell us a thing in that particular area".

Although we disagree with Wolpert, it is useful to have an 'absolute zero' to work against. Therefore we rephrase our question as *can we find at least one example in which art has contributed to science?* Figure 1 provides a possible example. Mitleton-Kelly (2003) writes: "If organisations are seen as complex evolving systems (CES), then the approaches, methods and tools that we use to study them and to help them evolve need to be appropriate - for example, they need to take the characteristics of organisations as CES into account; they need to track changes over time; and they need to address both the qualitative and the quantitative aspects of the organisation under study as well as its broader environment." In this paper Mitleton-Kelly sets out the comprehensive methodology she has developed to study human organisations: "During the analysis our resident artist, Julian Burton, will capture some of the themes, dilemmas and underlying assumptions in a picture. This has several advantages: many related aspects that are difficult to think about at the same time, can be captured in one picture; and very sensitive issues that are difficult to talk about, can be presented diagrammatically to workshop participants, before the presentation begins. Once they recognise what is being shown they may laugh and thus break the tension and open the issue(s) to discussion. One of Julian's pictures created for one of our business partners is at [Figure 1]".

"In addition, Julian Burton uses art to facilitate the process called 'Visual Dialogue'. This provides a visual perspective on important issues and challenges before, during and after meetings. The method can (a) capture the ideas, meanings, concerns and issues expressed in meetings, reflecting back emergent themes visually, as a catalyst for further discussion; (b) provide a visual overview of a current situation, expressing and conveying complex inter-related issues in context symbolically and

[1] Mark Lythgo, *The New Two Cultures*, BBC Radio 4, 25th April 2007. http://www.bbc.co.uk/radio4/science/thenewtwocultures.shtml

engage a group's attention thus enabling them to quickly grasp the main issues and focus on relevant elements; and (c) structure problems to facilitate shared sense-making, developing novel perspectives that can open up new possibilities in meetings." (Mitleton-Kelly, 2003).

Figure 1. Julian Burton's *Visual Dialogue* art (from Mitleton-Kelly, 2003).

In the terminology of knowledge engineering, this use of art could be interpreted as a means of *knowledge elicitation*. The implications are (i) that art can capture information that cannot be captured in other ways, such as tape recording, interview notes, or a questionnaire, (ii) that art can be used in a dialogue that elicits information in other ways, including subjects confirming or correcting the interpretation of previous interviews, (iii) that the work of art can be a way of enabling subjects to see their social situation in new and otherwise possibly threatening ways, and that (iv) that the work of art can be part of a social dynamic, enabling subjects to interact better with the social scientist and therefore be willing to provide information that they might otherwise withhold. Thus in this case art becomes part of a scientific *instrument*, and is part of the scientific process.

We believe this is a good example of art making a contribution to scientific method, and that it refutes Wolpert's view that art has nothing to contribute to science. Of course this example comes from *social science* which many natural scientists don't think is a science at all. Be that as it may, in the same radio programme Christopher Frayling of the Royal College of Art gives the following example from the natural sciences: "Fred Hoyle, [was] beginning to work in Cambridge in the late forties, on his theory of a cyclical cosmology that things don't move in a linear way, they move in circles. He goes to see a film in nineteen forty eight made by Ealing Studios called Dead of Night. Dead of Night begins with someone pulling up at a country house – it ends with the same scene of someone pulling up at a country house. In between all sorts of things have happened but the entire movie is cyclical. It ends where it begins. It begins where it ends. And he went home and wrote in his diary 'My God! It's a cosmology. Maybe there's something in this cyclical cosmology.' The art had reinforced the idea in Fred Hoyle's mind and off we go with Hoyle's cosmology of the fifties." Thus Frayling's example concerns art as *inspiration*.

2. Differences and similarities between art and complex systems science

Art	Complex Systems Science
Investigates relationships	Investigates relationships
Symbols communicate concepts	Symbols communicate concepts
Indifferent to consensus	Seeks consensus
Is subjective	Is objective [?]
Creates artefacts	Creates artefacts
Articulates theories of behaviour	Articulates theories of behaviour
Non-algorithmic search	Non-algorithmic search
Communicates ideas	Communicates ideas
World - Artist observational relationship	System – Scientist observational relationship
Artist as interpreter of observations	Scientist as interpreter of observations
Artefact – Viewer relationship	Theory – reviewer relationship
Stimulates new ideas	Stimulates new ideas
Obeys rules	Obeys rules (usually)
Avoids replicability	Seeks replicability
Builds on earlier work	Builds on earlier work
Break rules for new things	Don't break rules (often)

Table 1: Similarities between art and science

Table 1 suggests remarkable similarities between art and science (Johnson 2005(a)). For example, both art and science study *relationships* between things as illustrated in Figure 2(a), where the spatial relationship between Christ's apostles vividly portrays the story of the last supper. Jesus says that one of them would betray him, and each of the twelve apostles reacts in relation to the others. On the left, Bartholomew, James, and Andrew form a group. Judas, Peter and John form another. To the right of Jesus, Thomas, James, and Philip form another group. Matthew, Jude and Simon form the final group.

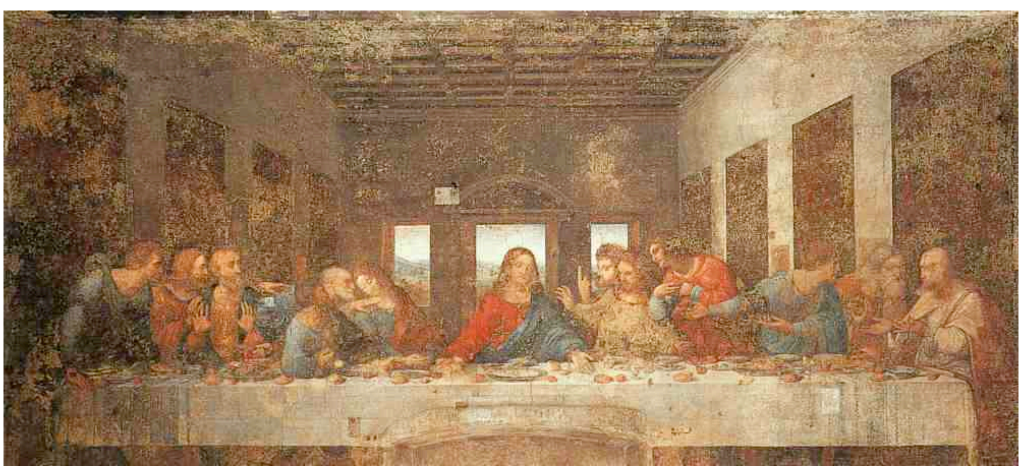
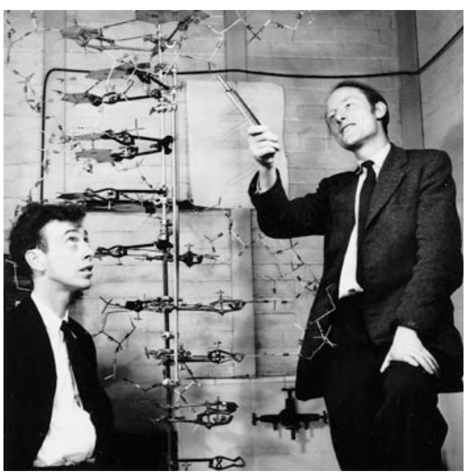


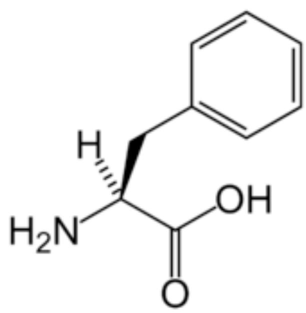
Figure 2. The Last Supper by Leonardo da Vinci, 1495-1498

"In common with other depictions of the Last Supper from this period, Leonardo adopts the convention of seating the diners on one side of the table, so that none of them have their backs to us. However, most previous depictions had typically excluded Judas by placing him alone on the opposite side of the table from the other twelve. Another technique commonly used was placing halos around all the disciples except Judas. Leonardo creates a more dramatic and realistic effect by having Judas lean back into shadow. He also creates a realistic and psychologically engaging means to explain why Judas takes the bread at the same time as Jesus, just after Jesus has predicted that this is what his betrayer will do. Jesus is shown saying this to Saints Thomas and James to his left, who react in horror as Jesus points with his left hand to a piece of bread before them. Distracted by the conversation between John and Peter, Judas reaches for a different piece of bread, as, unseen by him, Jesus too stretches out with his right hand towards it. All of the angles and lighting draw attention to Christ. … The painting contains several references to the number three, which may be an allusion to the Holy Trinity. The Apostles are seated in groupings of three; there are three windows behind Jesus; and the shape of Jesus' figure resembles a triangle. There may have been many other references that have since been lost to the painting's deterioration." (Wikipedia, Leonardo da Vinci, 2007).

The *composition* of works of art, where the spatial relationships and alignment of things creates and conveys structures and meanings, is similar to *models* or *compositions* of physical systems, such as the double helix proposed by Crick and Watson (Figure 3(a)). In both art and science, compositions are formed from *elements* represented by *symbols* that have their own meaning. Thus the symbol OH in Figure 3(b) means the (sub) combination of oxygen and hydrogen atoms, while hexagonal configuration signifies a benzene ring formed of carbon and hydrogen atoms. To understand chemistry it is necessary to learn these symbols and what they signify. Similar symbolism is used in art. For example, in Raphael's picture *The Coronation of the Virgin* (c. 1503) Figure 3(c) the white lilies symbolise the purity, chastity, and innocence of the Virgin Mary. The Angel Gabriel was often painted presenting Mary with a white lily when he announced to her that she would give birth to the Son of God. Colours are also symbolic in art: white symbolizes the purity of the soul, innocence, and holiness; black is an ancient symbol of death and mourning; green symbolizes life and vegetation, and is an emblem of the resurrection; red is the colour of love, anger, passion, and blood and so on.



(a) double helix as a composition



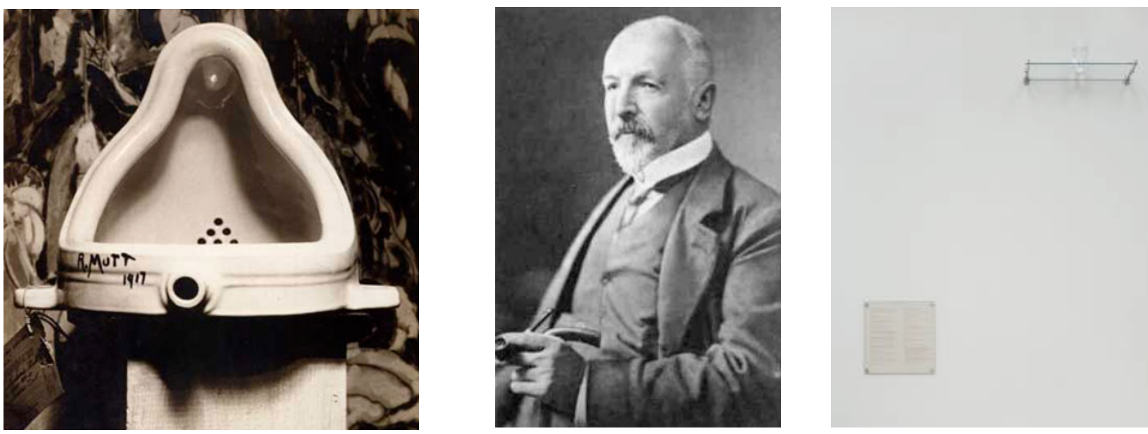
(b) symbols in chemistry

(c) the lily symbolizes purity

Figure 3. Both art and science use symbols signifying particular things in the context of compositions

Perhaps one of the major contemporary differences between science and art is that the former seeks consensual answers whilst the avant-garde of Modern Art conventionally seeks to provoke questions and conflicting views. Thus, whilst scientists have established *methods* of observation and argument on which they agree almost universally, giving them common ground to explore their differences on any particular thing, Modern Artists have been characterised more profoundly by schools of thought and bodies of work. Hermeneutics may give a consistent basis to explore across these boundaries.

As an example of Modernist avant-gardism, the work of artist Marcel Duchamp sought to undermine not only the art establishment but also the avant-garde community to which he belonged. He created *Fountain* from a 'ready made' Bedfordshire model urinal bought from the Mott Iron Works in New York and writing on it "R. Mutt 1917". Duchamp was a board member of the Society of Independent Artists in New York and submitted the Fountain under the name R. Mutt to its 1917 exhibition. The Board had previously declared its intention to exhibit all work submitted. After much debate about whether the piece was or was not art, Fountain was hidden from view during the show. Duchamp resigned from the Board after the exhibition, having shown that even the avant-garde Dada movement could dissimulate and be narrow-minded. Duchamp's recontextualisation of the manufactured object as art object was far more than the narcissistic gesture of an 'enfant terrible'; the reappropriation of found objects and ready-mades at this time was a poignant statement about the role of the artist and the notion of artistic value and authenticity in an age of mechanical reproduction[2] and his work heralded a paradigm shift in the function of the artist and of art. Today, collage, montage and using secondary sources is a natural part of contemporary visual culture. It is all to easy to forget that until the late 1800s the role of the artist was to document, first hand, people, events and places (Fig. 5).



(a) Duchamp's *Fountain* (b) Georg Cantor, (c) Craig Martin's *Oak Tree*

Figure 4. Challenging accepted norms

The world of science is subject to similar social forces of conservatism. For example, Cantor (1845-1918), who gave us set theory and an operational definition of infinity based on one-to-one correspondence, encountered resistance from mathematical contemporaries such as Kronecker, Poincaré, Weyl, and Brouwer. Today the theories of cardinal and ordinal numbers are seen as a major paradigm shift in mathematics and science.

Figure 4(c) shows *The Oak Tree* produced by Michael Craig-Martin in 1973: "While this appears to be a glass of water on a shelf, the artist states that it is in fact an oak tree. Craig-Martin's assertion addresses fundamental questions about what we understand to be art and our faith in the power of the artist. The work can be seen as an exploration of Marcel Duchamp's declaration that any existing object can be declared a work of art. In his accompanying text, Craig-Martin provides the questions as well as the answers, allowing the simultaneous expression of scepticism and belief regarding the transformative power of art."[3]

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[2] Benjamin, W., (1937) The Work Of Art in the Age of Mechanical Reproduction, http://www.marxists.org/reference/subject/philosophy/works/ge/benjamin.htm

[3] http://www.tate.org.uk/servlet/ViewWork?workid=27072 (13th May 2007).

It is difficult to find support for genuinely new ideas. Like the Society of Independent Artists, funding bodies may claim that they want to support 'blue-sky' research, but faced with ideas outside accepted norms funders tend to stay with what is known and safe. With some notable exceptions, the complex systems community experiences the difficulties of finding support for work that cuts across accepted and entrenched subject domain boundaries. For example, some may see this paper as frivolous or misguided, and agree with Wolpert that art can contribute zero to science in general, and that art can contribute zero to complex systems in particular.

Whereas practitioners in mathematics and natural systems are considered to be 'outside' the system, researchers cannot avoid being embedded in the social, socio-biological, socio-informational, and general socio-technical systems that the new science of complex systems is attempting to unravel. Traditional science claims objectivity, but it is questionable that complex systems science can claim equal objectivity. Natural scientists know that observing a system may change its behaviour. This is even more obvious in social science where, for example, an anthropologist may intervene to save a life, and thereby disrupt the 'natural' evolution of a society. Social scientists have developed methods for collecting data on human systems by being part of them, and there is much for complex systems scientists to learn from contemporary ethnography and anthropology.

Methods of representation in, say, chemistry have been developed incrementally over two centuries or more, and there is stability in the representation of water as H_2O and carbon dioxide as CO_2. In comparison, artists keep revisiting things and finding new ways of seeing and interpreting them over time and across space. There is a growing belief that complex systems may not admit fixed 'ontologies', which is sometimes seen as the goal the goal of traditional science. What if the fixed ontology were to be one of relativity ?

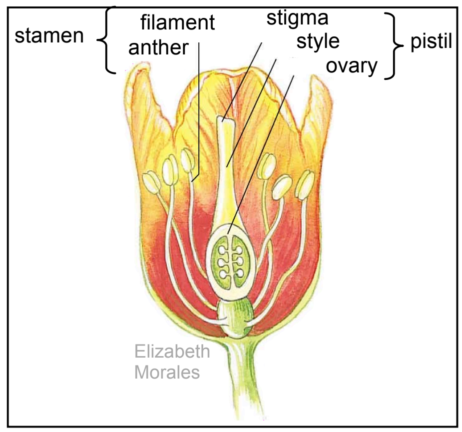
Writing of innovation in social systems, Lane and Maxfield (2005) suggest three kinds of uncertainty: *truth uncertainty* when the truth of a well-defined proposition is uncertain; *semantic uncertainty* when actors are uncertain what a proposition means; and *ontological uncertainty* where there is uncertainty in the kind of *entities* that inhabit actors' worlds, uncertainty about the kinds of *interactions* actors can have between themselves, and uncertainty how the entities and interaction modes *change* as a result of the interactions. In other words, innovative social systems are characterised by requiring knowledge of them to be *dynamic* at the most fundamental levels of interpretation. This is completely different to natural science seeking more-or-less fixed ways of representing systems on which there is more-or-less universal consensus among the scientific community. While it seems unlikely that physics will undergo a major shift in the way it represents the physical universe, it seems axiomatic that the representation of social systems *must* change through time, because the systems themselves do. For example, if we had maintained the ontology of the nineteenth century we would have no language to represent computers, networks, and the completely new economics phenomena of the modern world.

In computer science the idea of *folksonomy* is being developed as a practical means to allow vocabulary to emerge from individuals 'tagging' photographs and other objects with their own personal vocabulary. By its nature such vocabulary reflects usage, and varies over time.

Thus the science of complex systems needs new ways to build ontologies, with dynamic vocabulary formation, and new ways of representing inevitable ontological uncertainties. One answer might be to recognize the use of *narrative*: "Narrative is the linguistic form we use to communicate human experience and render it meaningful to one another and to ourselves. A narrative relates a series of events, with, as Aristotle pointed out, a beginning, a middle and an end. More specifically, a narrative consists of a cast of characters, a plot that structures the events temporally, and a denouement in which the fortunes and even identities of some of the characters change from what they were at the story's beginning. The characters' identities can be crudely but usefully summarized as "what they do and how they do it". Plot development consists of the characters acting out their identities in contexts that are determined by their previous actions, the actions of the other characters, and events from the world outside – including coincidences and catastrophes (wars, market crashes, floods…) that the narrator and listener regard as 'normal,' that is consistent with some implicitly agreed-upon natural or social "laws", and beyond the control of the story's characters." (Lane and Maxfield, 2005).

Can science be story-telling? According to Jean Francois Lyotard, in *La Condition postmoderne: Rapport sur le savoir (The Postmodern Condition: A Report on Knowledge)* (1979) the idea that everything is knowable by science is a grand narrative in itself; the theories derivative of that position meta-narratives. If a theory works in the field it doesn't mean it is not a narrative; all knowing is narrative knowing.

Are complex systems too subtle to be represented using the gold standard narrative of mathematics? By its very precision is mathematics inappropriate for representing systems? Can mathematics capture the nuances of love, hate and the spectrum of emotion in between? Can it aggregate these highly dynamic micro-relations to the macroscopic structures of geopolitics, security, and climate change? Without losing essential information in telling the story? Or are the complex systems scientists of the future to be novelists and poets?



(a) Self Portrait, Joshua Reynolds (1780) (b) Drawing of a flower

Figure 5. Until the late 18002 the role of the artist was to document, first hand, people, events, objects and places

Although many natural scientists despise the use of natural language a mode of representation in the social sciences, almost all science uses the vernacular as its meta language. For some sciences, such as botany, the favoured method of representation has traditionally been a mixture of words and pictures. For example, the definition of 'flower' given by the Free Dictionary[4] is "(a) The reproductive structure of some seed-bearing plants, characteristically having either specialized male or female organs or both male and female organs, such as stamens and a pistil, enclosed in an outer envelope of petals and sepals, (b) Such a structure having showy or colorful parts; a blossom." accompanied by the picture in Figure 5. Certainly drawings and images form part of the narrative of science.

An obvious interplay occurs between art and science in that both communicate ideas, and that they often use common methods of representation. Is cartography art or science? Is computer graphics art, technology, or science? Is the drawing in Figure 5 art or science? Representation and the way we 'read' representation is fundamental in science. In the science of complex systems there are many outstanding issues in these regards, not least the 'boundary problem' of discriminating between systems, between subsystems, and between parts of subsystems.

[4] http://www.thefreedictionary.com/flower, (referenced 9th May 2007)

The concept of the 'open work' (Eco 1962) has been an established post modern concept in the arts for over 30 years. It is commonly recognized as a feature of installation and, more recently, of interactive art as a reflection of the artist's conscious decision to leave part of a work open to interpretation. It is not difficult to apply this concept in varying degrees to many artistic artefacts and experiences, for example, surrealist montage, poetry, the writings of James Joyce, etc. It is even commonly recognized in advertising design, as a purposive space for engagement and interpretation of a message, without which the communication doesn't 'work'.

Post modern rejections of grand narratives don't necessarily exclude the new scientific paradigm of complexity. Lyotard's (1979) political and linguistic reasons why postmodern art celebrates plurality, denies any progress towards singular totalizing views, yet what happens if that singular totalizing view incorporates interactivity? Surely complexity is pluralistic by its very nature? In the same vein, Derrida's (1962) emphasis on a 'break with structuralism' and his denial 'that language corresponds to innate and specific mental representations', is more a break with formalism than anything excluded by complexity.

One could argue that as complexity is derivative of interaction, and all interaction is based upon some form of system (Saussure's 'langue', 1998), developments in complexity science may best be pursued by applying linguistic paradigms from hermeneutics. Arguably, literary theory, semiotics, deconstruction, textual analysis and discourse analysis were the first fields to embrace complexity and as such they provide ample functional methodologies for scientific modelling. Whilst some social scientists apply Newtonian cause and effect to little result in the behavioural sciences, linguistics is the study of our primary complex systems? It extrapolates across media & cultural studies to include visual communication and digital culture works. Although alien to many, these modes of thought and practices could offer much to complex systems scientists

3. Complex Embrace

Complex Embrace was a experimental art-science collaboration between the artist Damian Gascoigne and the complexity scientist, Jeffrey Johnson. It resulted in a public exhibition at the Picker Gallery in Kingston, London in December 2005[5]. The context was the research project *Embracing complexity in Design*[6], itself one of twenty one research clusters in the *Designing for the 21st Century* initiative of the UK Arts and Humanities Research Council and Engineering and Physical Science Research Council[7]. *Embracing Complexity in Design* started from the premises that designed artefacts and systems can be complex; manufacturing and fabrication systems can be complex, the social & economic environment of design is complex, and that the design process itself is a complex human cognitive system.

Gascoigne was commissioned by the cluster with the brief to *create an artwork that would stand in its own right, and stimulate the viewer to reflect on some of the ideas of complexity science*.

It is clear that art can be complex in many ways. The driving force behind *Complex Embrace* was whether art can complement science and vice-versa in the search for understanding of complex systems. Being too prescriptive could result in an outcome that was neither interesting art nor a contribution to science, and the brief was left deliberately loose, with an emphasis on creativity.

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[5] http://www.kingston.ac.uk/picker/archive/2005/Damian%20Gascoigne/index.htm
[6] http://www.complexityanddesign.net/
[7] http://www.design21.dundee.ac.uk/

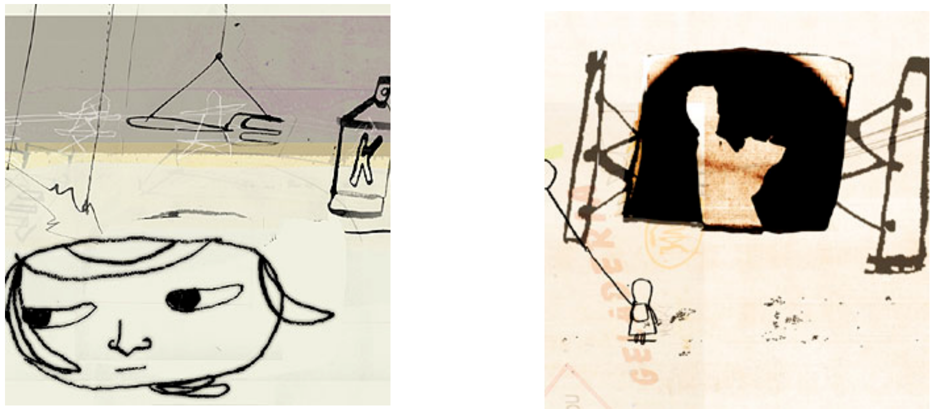


Figure 5. Examples of Gascoigne's 'computer-aided' hand-drawn animation technique.

Rather than try to explain complexity through animation Damian decided to take on the idea of an unpredictable and frustrating search for answers in these areas of science and to create an animated system that was subject to some of the unpredictability and liability to change that would be beyond his control. "I became interested in emergence and drift – what scientists call sensitivity to initial conditions."

(a) Gascoigne's new spatial sequence method of drawing (b) the 3-part screen of the installation

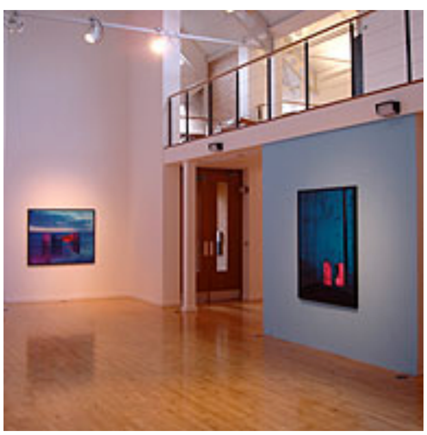
Figure 7. The artistic breakthrough that led to the final installation

The installation idea was Damian's lateral way of looking at how a combination of things might come together to form a new outcome. "What was important to me to make it as close to an experiment as I could and to set it up so that I only had a certain amount of control over the outcome, and not complete control." … "The content of the imagery all came out of the idea of sensitivity to initial conditions. From the start I wanted to explore the concept of how things drift from their start point and translate that idea into some animated sequences."

During the collaboration, Gascoigne tried something caused him great excitement: "The working method I stumbled upon to create the sequences was something that I'd never done before. I decided to work by doing an initial drawing and making a sequence of drawings *alongside* rather than *on top* of the last one. This gave me a certain amount of control but not anything like the level of control one usually uses in animation. The results of these experiments form the heart of the visual content in the piece (Figure 7)."

Gascoigne's normal way of work had been to draw an object, then draw a slightly transformed version on top of it for the next animation frame, then draw a slightly transformed version on top of that, and so on until a sequence of registered frames for an animated sequence emerged[8]. However, the tension was rising. The exhibition was a few weeks away, and the project was becoming high-risk. It could turn out very well, or it could be a disaster.

The gallery where the installation would be exhibited had a very high ceiling, and this impacted on Gascoigne's plan for the installation: "Three projectors are set in a stack, one on top of the other, showing three equal length animated sequences. However the combination of differences in lengths of individual sequences and the vagaries of the timings of individual DVD players will create a drift in terms of the relationships between the sequences on each screen, creating ever changing combinations that drift in and out of phase with each other."



(a) part of the gallery

(b) part of installation

Figure8. The context for Gascoigne's installation

By investigating drift and control, Gascoigne brings us to other important ideas. Some systems are unpredictable because they are sensitive to initial conditions. For example the three machines playing the animations are all started "in the same way", with minor immeasurable differences. As time progresses they drift, a process is exacerbated by the restart mechanisms which may add small random

[8] These drawings acted as the 'key' frames, with the computer doing the 'in-betweening' to make the animation smooth. This technique produces computer animations that have a similar fine-art quality to more traditional hand animation, as can be seen in Figure 5.

factors. Will it be the case that every viewer sees something different? The process of working that Damian describes puts him in a vicarious position between total control of the animation and randomness. Some scientists call this *the edge of chaos* and claim it reflects regions of energy and creativity." Gascoigne's work also reflects other aspects of complex systems. It is *path dependent*. Things done early in the process may not appear in the finished piece, but affect later decisions. Some systems are unpredictable because we don't know their entire history, and the affects of early events.

The exhibition took place 30th November – 17th December 2005, and was well received. But did any new scientific ideas emerge? Gascoigne and Johnson (2007) suggest they did. Certainly the process illustrated many concepts of complex systems science, and suggested an interesting line of research into subjective time. The aim to *stimulate the viewer to reflect on some of the ideas of complexity science* was not achieved, but like an experiment with unexpected negative results, this leads to new ways of approaching the objective of expressing and communicating the new science..

4. String theory

In 2005 the artist Michael Petry participated at the Complexity Symposium *Art, Complexity and Technology: Their Interaction in Emergence* organised by the EC Exystence coordination action at Villa Gualino in Torino, May 5-6, 2005[9]. "This would be an interactive self-defining, ongoing project that would take place at the start of the conference and run throughout its 2 days. A final visual element will emerge from the participation of all the conference members, speakers as well as attendees."[10]

Figure 8. Michael Petry's *Superstring* installations

"According to lead theorists (like David Peat) super strings run throughout the universe taking material from one end to another. Yet they interact on our perceived notion of the universe at such an infinitesimally small level, that we do not see or feel these transfers. Such strings are said to pass through our physical bodies continuously going through the space between atoms, and subatomic particles. Particles like neutrinos are so un-interactive that they pass through us without ever disrupting our subatomic elements. Petry would ask each person to attach at least one section of string to different parts of the room (with staplers provided) at the start of every session. They could of course do many, or use the break periods to make even greater interventions. … In essence, the room will become wrapped in miles of elastic string, going from floor to wall, ceiling to door, wherever anyone wanted to attach two end points. Viewers would eventually be able to enter and bounce around the space. … Often it is asked how artists can lead scientists to an understanding of the world, and while there are many examples, Petry would suggest that the visual metaphor of the bound room being a pattern for space, and yet a bound restricted space presents a paradox similar to that of the Wormhole. In a Wormhole, given the technology, we could as we exited one, see ourselves enter it. In a bound room, the depiction of freedom and its boundaries can be drawn and complexity will see art and science merge."[10]

[9] http://www.psych.lse.ac.uk/complexity/Symposium/TorinoMay05.htm (referenced 9th May 2007)
[10] http://www.psych.lse.ac.uk/complexity/Symposium/torino/superstring_installation.htm (9th May 2007)

Petry's work caused visible irritation in some of the physicists at the Torino meeting. It depended on *metaphor* in almost every way. Certainly for these scientists, art had nothing to add to their mathematics. However, string theory itself is controversial: "The experimental situation is similarly bleak. It is best described by Wolfgang Pauli's famous phrase, "It's not even wrong." String theory not only makes no predictions about physical phenomena at experimentally accessible energies, it makes no precise predictions whatsoever. Even if someone were to figure out tomorrow how to build an accelerator capable of reaching the astronomically high energies at which particles are no longer supposed to appear as points, string theorists would be able to do no better than give qualitative guesses about what such a machine might show. At the moment string theory cannot be falsified by any conceivable experimental result."[11] Perhaps the string theorists have got it wrong, building abstract mathematical edifices of great fascination and beauty that are themselves metaphors of some observable reality? More art than science? Perhaps metaphorical interpretation of the physicists' metaphorical interpretation could lead to different, more apposite metaphors, moving the search for answers to deep questions in physics to new parts of the scientific search space?

5. A new experiment

On discussing Gascoigne's reappraisal of synchronicity and image sequencing in his work with Johnson, Cham described a video installation she had made in 1995 to document Louisa MacIvers (1995) time-based performance work, 'The Pledge of Fidelity…'. Exploring how to effectively document an activity that took place over a prolonged period of time (3 months), Cham & MacIver devised a surveillance model (pre- reality TV precedents) to document the repetitive elements of the MacIvers day to day life. This was then made into three video loops each of a different duration (20 mins; 8 mins; 1 min) which were projected onto three separate walls of the Ferens Gallery, Hull. An edited transcript of the artist's audio diary was broadcast concurrently on a 30 minute loop. It was an intentional juxtaposition of repetitive actions on different time bases, with subjective reflection on a further time base to reflect the complexity of MacIvers experiment, thus ensuring the greatest possibility of emergent narrative for the visitor.

Cham's earlier sculptural work consistently explored emergent meaning. Combining interactions of the basic design forms of the line and the circle, her work was a continual and persistent exploration of Derrida's (1967) proposition that 'language is an unfixed system of traces and differences …. regardless of the intent of the authored texts … with multiple equally legitimate meanings'[12]

Cham went on to describe an installation (Figure 9) in which she had created numerous suspended sculptures from springs and water filled balloons 'Dead Celebrities' (2002). The work perished over time and in response to people's intervention; 'some springs stretched to the floor where the water filled balloons lay like drunken worms, whilst the water in other balloons had swung to one end and burst free, leaving a puddle on the floor and the ragged balloon hanging high in the air with the proud spring blissfully unaware of its loss.'

Following Petry's Superstring example, for our forthcoming exhibition-workshop *Art in the Science of Complex Systems*[13], we will ask people to participate in the creation of a new object. We decided to use similar components to those Cham had used in her 'language' sculptures, but with a tight palette of component parts available for people to mark up and utilise in the construction process. Johnson suggested videoing the process, Cham suggested an annotated video where the users' selections and mark up would be highlighted on screen as further means of recognising the modelling process. To ensure the making process takes place in as controlled a way as possible, Isabel Jones, an expert in participatory processes will facilitate.

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[11] http://www.americanscientist.org/template/AssetDetail/assetid/18638?&print=yes (9th May 2007)
[12] Galanter,P., (2002) **Against Reductionism:** Complexity Science, Complexity Art, and Complexity Studies
[13] *Art in the Science of Complex Systems*, Lighthouse Gallery, Brighton, 13-16 June 2007.

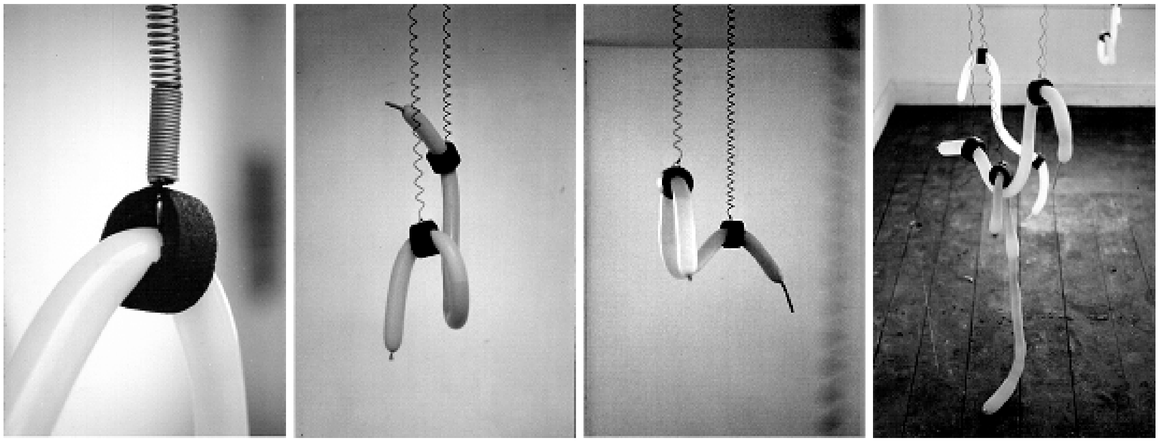

Figure 9. Dead Celebrities, Karen Cham (1992)

At this stage in the process (May 2007), we don't know what the outcome of the experiment will be. We hope the outcome will be the successful documentation of a complex process. By the time this paper is presented at ECCS'07 (we hope!) the experiment will be complete and we will be able to report on it in the published revised version. So we take the opportunity of making some *predictions*.

<u>Prediction 1</u>. People *will* participate.

This prediction is based on past experience: in this kind of environment in the past people have participated. We can speculate on their motivation. Perhaps at scientific events, people want to help other scientists achieve their objectives. Perhaps at artistic events people want to express their creativity, or be part of some larger expression of humanity. And perhaps some people are just curious, or enjoying the fun.

<u>Prediction 2</u>. A complicated object will emerge.

This predication is based on experience with *generative* systems. We will put in place rules for combining the components. Since the number of ways the components can be put together is large, for combinatorial reasons we expect a complicated object to emerge.

<u>Prediction 3</u>. Something entirely unexpected will emerge.

This prediction is based on the optimistic expectation that someone will do something we had not expected that will take the *trajectory* of our sculpture will take a 'branch' that will surprise us. This kind of prediction is highly problematic. What do we 'expect'? How can we measure it. What is 'surprise', and how do we measure that?

<u>Prediction 4</u>. Something entirely unexpected will *not* emerge.

This prediction is based on the experience that "you win some and you lose some". Perhaps the people attending our event will be rather dull an inhibited? Perhaps we will be too prescriptive, pre-empting any real innovation.

<u>Prediction5</u>. Some people will say our object is not art, or is bad art, or has no artistic merit.

<u>Prediction 6</u>. Some will say our experiment is flawed, not science, or that it has no scientific merit.

These two predictions illustrate that that both art and science are socially situated. Generally artists don't care what the critics say, and nor do scientists if they believe they are right. Scientists perhaps try harder to persuade each other, but even they may have to 'agree to differ'.

We make these ‘predictions’ as part of our experiment in which we are attempting to *engineer emergence*, even when we don’t know what will emerge. In contrast, those engaged in engineering and policy should know the desired outcomes, and make ‘predictions’ that their actions will result in the desired outcome.

What does it mean to make a prediction? How will we know if our predictions are correct? Perhaps this will be a one-in-a-million event where nothing interesting happens. So perhaps we should run this event millions of times to give a statistical dimension to our predictions? Of course we can’t, because it would be too expensive and take too long. Also, we could not repeat the experiment because the *initial conditions* could never be the same. This is a typical complex systems experiment. We can set it up once, run it one, record what happens as best we can, and try to reconstruct a theory from the data. Following the traditions of social science we can construct a narrative of this process, and following the traditions of art we can create an edited video recording of the evolution of our object. What we can construct of a scientific nature remains to be seen. We will consider this further when our experiment is complete. What is interesting at the time of writing is the idea of designing the components and annotating the video of their use to investigate the dynamics of the process and our ability to ‘predict’ the outcome in a rigorous way.

6. Conclusions

We have asked *what contribution can art make to the science of complex systems,* and whether *art can become part of the scientific process*.

- data collection: Burton and Mitleton-Kelly’s work provides an example where art becomes a powerful part of instrument for data collection, enabling people to provide information on their social systems that cannot be elicited using other methods. Although alien to many natural scientists, the modes of data collection of the ethnographer and anthropologists seem natural for investigating complex socio-technical systems. As shown by Burton and Mitleton-Kelly, art can add new dimensions to this.
- art can be a source of inspiration, as in the case of Hoyle’s theory of cyclical cosmology.
- There are many similarities between art and science, especially in their common concern with representing objects and ideas, and finding new ways of thinking about things. Art offers much to science by its ability to *communicate* complicated ideas in accessible ways.
- We have discussed art in the context of the conflicting modes of thought where researchers discover immutable truths about systems from the outside, or create narratives and tell stories about systems from the inside. Literary modes of thinking and representing systems contrast starkly with the accepted scientific methods, but they may provide new ways of exploring and understanding the dynamics of complex systems. Hermeneutics may contribute to the science.
- We have reported on experiments generating artworks to explore the interaction between complex systems science and art. In this context we have made a series of ‘predictions’ to investigate the dichotomy of scientist-inside-the-system and scientists-outside-the-system. The results of this experiment will be reported when the experiments are completed in June.

The example of Burton and Mitleton-Kelly shows conclusively that art *can* contribute to science. Going beyond this, and exploring other aspects of art, we conclude that art can play a powerful part in the science of complex systems.

References

About Inc., (2007) *Symbols of Christian Art*, http://altreligion.about.com/library/glossary/symbols/blchristiansymbols2.htm

Benjamin, W., (1937) The Work Of Art in the Age of Mechanical Reproduction, http://www.marxists.org/reference/subject/philosophy/works/ge/benjamin.htm

Cham, K.L., (2002) Dead Celebrities, ready mades installation, 83a Opens, Bold St, Liverpool.

Derrida, J., (1967) W*riting and Difference*, University of Chicago Press

De Saussure, F., (1998) *Course in General Linguistics*, Open Court Classics

Eco, U., (1962) *The Open Work*, Harvard University Press.

Free Dictionary http://www.thefreedictionary.com/flower, (referenced 9th May 2007)

Galanter, P., (2003) Against Reductionism: Science, Complexity, Art & Complexity Studies, http://www.google.com/search?q=cache:mX7zBtwdTD8J:isce.edu/ISCE_Group_Site/webcontent/ISCE_Events/Norwood_2002/Norwood_2002_Papers/Galanter.pdf+art+%26+complexity&hl=en&ct=clnk&cd=2

Gascoigne, D., Johnson, J .H., (2007) 'Complex Embrace: Exploring Complexity Through Art', submitted to the European Conference on Complex Systems, ECCS'07.

Johnson, J. H., (2005a) 'Art, Relationships and Complexity Science', *Complexity & Art*, Int. Conference on Complexity, Science and Society, Liverpool University, 11-14th September 2005.

Lane, D., Maxfield, R., (2004) 'Ontological uncertainty and innovation', *Journal of Evolutionary Economics*, **15**, 3-50. http://www.santafe.edu/research/publications/workingpapers/04-06-014.pdf

Lyotard, J.F., (1979) The Postmodern Condition, Manchester University Press

Lythgo, M., (2007) *The New Two Cultures*, BBC Radio 4, 25th April 2007. http://www.bbc.co.uk/radio4/science/thenewtwocultures.shtml

MacIver, L., (1995) The Pledge of Fidelity, The Pledge of Self Discipline; time based art and video installation, commissioned by Hull Time Based Arts for ROOT at the Ferens Gallery, Hull

Mitleton-Kelly, E., (2003) 'Complexity Research - Approaches and Methods: the LSE Complexity Group Integrated Methodology', in Keskinen A, Aaltonen M, Mitleton-Kelly E (eds), *Organisational Complexity*. Foreword by Stuart Kauffman. Scientific Papers 1/2003, TUTU Publications, Finland Futures Research Centre, Helsinki, 2003. http://www.psych.lse.ac.uk/complexity/Publications/New_Folder/Methodology.pdf

Wikipedia, Leonardo da Vinci, referenced 28th May 2007).http://en.wikipedia.org/wiki/The_Last_Supper_(Leonardo)#Composition_and_meaning